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THE

Progressive Fish-Culturist

UNITED STATES DEPARTMENT OF THE INTERIOR
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EFFECT OF STARVATION AND FEEDING ON THE CHEMICAL COMPOSITION OF BROOK TROUT

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and
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STUDIES OF CHEMICAL CHANGES IN A TROUT'S BODY DURING PERIODS OF GROWTH AND STARVATION can provide information about changes in its metabolic activity. The effect of starvation is important because an insufficient food supply for hatchery trout after their stocking may be a factor in their survival. The effect of feeding on the chemical composition of fish may indicate the efficiency and utilization of dietary ingredients. Few studies on periodic changes in the body chemistry of growing fish have been reported. Most studies on starved fish have reported mortality and loss in weight but have given little attention to changes in body chemistry. Phillips and his cowriters (1953) measured changes in the body weight of brook and rainbow trout under starvation conditions; at the end of the experimental period they analyzed the livers for fat, water, and four members of the vitamin-B complex, and analyzed the blood for glucose.

During the summer of 1959 samples of starved and fed brook trout (Salvelinus fontinalis) were taken at weekly intervals to determine changes in their chemical composition over an extended period.

Method

Brook trout were held in water at temperatures of either 47° or 58° F., and were either fed the standard Cortland hatchery diet [1/] or starved until excessive mortalities occurred. It was possible to continue these experiments for 12 weeks. At weekly intervals the trout were weighed and samples of fish were preserved in formalin for chemical analysis. All the experiments were run in duplicate, and duplicate weekly samples of fish were taken from each experiment for analysis.

Prior to chemical analysis, the fish samples were dried to constant weight in a vacuum oven to determine moisture. The dried samples were then analyzed for fat, protein, and ash.[2/]

The data are summarized in tables 1 through 4 and plotted in figures 1, 2, and 3. Significant differences were established by analysis of variance.

Analytical Results

Weight.--During the 12 weeks of the experiment, the weight of the fed fish

1/Diet composition: Beef liver and beef spleen, 22 percent each; dry meal mixture, 56 percent. Dry meal mixture: 24 parts each of fish meal, cottonseed meal, distiller's solubles, and wheat middlings; 4 parts of salt.

2/Analytical methods: Protein, micro-Hengar; fat, continuous ether extraction; ash, ignition to constant weight.

TABLE 1.--Effect of starvation and feeding on brook trout held at a water temperature of 47° F. over a 12-week period

Time (weeks)	Average weight (grams)	Dry basis			Wet basis			
		Percent protein	Percent ash	Percent fat[1]	Percent water	Percent protein	Percent ash	Percent fat[1]
				Trout starved				
0	2.31	57.5	7.60	26.4	79.7	11.7	1.54	5.4
1	----	54.5	8.11	25.5	80.0	10.9	1.62	5.1
2	----	56.3	8.85	25.1	78.9	11.9	1.87	5.3
3	----	54.2	9.13	22.7	79.3	11.2	1.89	4.7
4	1.96	59.7	10.01	24.0	79.6	12.2	2.22	4.9
5	----	53.4	10.08	21.2	78.3	11.6	2.33	4.6
6	----	57.7	11.30	22.4	81.3	10.8	2.11	4.2
7	----	54.2	11.75	22.9	79.5	11.1	2.41	4.7
8	1.90	60.1	12.50	21.0	80.9	11.5	2.39	4.0
9	----	61.8	13.28	20.1	81.1	11.7	2.51	3.8
10	----	57.0	12.35	20.4	78.9	12.0	2.61	4.3
11	----	58.4	14.20	20.2	81.2	11.0	2.67	3.8
12	1.85	62.4	14.65	20.6	83.5	10.3	2.42	3.4
				Trout fed				
0	2.31	57.5	7.60	26.4	79.7	11.7	1.54	5.4
1	----	54.5	8.10	24.8	78.5	11.7	1.74	5.1
2	----	53.7	8.03	25.2	77.8	11.9	1.78	5.6
3	----	55.5	8.10	23.4	76.5	13.0	1.90	5.5
4	3.73	60.5	8.32	24.5	77.6	13.6	1.86	5.5
5	----	49.6	8.07	24.3	75.8	12.0	1.95	5.9
6	----	58.6	8.13	25.8	77.5	13.2	1.83	5.8
7	----	55.1	8.06	25.6	76.2	13.1	1.92	6.1
8	6.05	59.1	7.95	26.8	75.8	14.3	1.92	6.5
9	----	58.0	7.76	29.3	74.1	15.0	2.01	7.6
10	----	53.0	7.53	27.3	71.4	15.1	2.15	7.8
11	----	52.5	7.20	29.4	72.5	14.4	1.98	8.1
12	9.30	54.1	7.62	33.4	74.0	14.1	1.99	8.7

[1] Ether extract.

increased as expected. The total gain of the fish held in the warmer water was approximately 850 percent, and that of the fish held in the colder water was approximately 300 percent. Over the 12-week period, the starved trout held in the warmer water lost about 31 percent and those held in the colder water lost about 20 percent. The total weight loss of the starved fish was surprisingly low, considering the length of the experimental period (tables 1 and 2).

Mortality.--No mortality of fed fish occurred during the experimental period, and the mortality of the starved fish was negligible until the 10th week. By the end of 10 weeks and continuing throughout the remainder of the period, there was increased mortality among the starved fish (table 3).

Water.--Water content in the bodies of the starved trout increased with the passage of time, while the opposite was true for the fed trout. Both the increase in water content of the starved fish and the decrease in water content of the fed fish were greater in the warmer water than in the colder water.

In all groups of fish there were peaks in water content which were followed by

TABLE 2.--Effect of starvation and feeding on brook trout held at a water temperature of 58° F. over a 12-week period

Time (weeks)	Average weight (grams)	Dry basis			Wet basis			
		Percent protein	Percent ash	Percent fat[1]	Percent water	Percent protein	Percent ash	Percent fat[1]
				Trout starved				
0	2.31	57.5	7.60	26.4	79.7	11.7	1.54	5.4
1	-----	54.9	8.62	24.5	79.6	11.2	1.76	5.0
2	-----	57.5	9.10	25.5	80.0	11.5	1.82	5.1
3	-----	60.7	10.65	22.9	80.4	11.9	2.09	4.5
4	1.77	60.6	11.10	21.9	77.2	13.8	2.53	5.0
5	-----	59.4	11.85	22.0	79.5	12.2	2.43	4.5
6	-----	56.7	12.45	20.5	82.0	10.2	2.24	3.7
7	-----	57.6	14.39	17.6	85.2	8.5	2.13	2.6
8	1.74	58.8	15.50	16.4	82.3	10.4	2.75	2.9
9	-----	54.8	16.90	14.5	83.4	9.1	2.79	2.4
10	-----	54.0	16.50	17.7	82.0	9.7	2.97	3.2
11	-----	58.3	18.65	17.2	84.9	8.8	2.82	2.6
12	1.60	59.7	22.20	12.1	85.9	8.4	3.13	1.7
				Trout fed				
0	2.31	57.5	7.60	26.4	79.7	11.7	1.54	5.4
1	-----	53.1	8.35	25.5	78.0	11.7	1.84	5.6
2	-----	55.3	8.15	23.5	77.4	12.5	1.84	5.3
3	-----	59.5	8.21	23.9	77.8	13.2	1.82	5.3
4	5.10	58.7	8.40	23.2	76.3	13.9	1.99	5.5
5	-----	56.7	9.25	24.2	76.0	13.6	2.22	5.8
6	-----	56.5	9.06	23.8	77.3	12.8	2.06	5.4
7	-----	55.7	8.53	25.0	77.6	12.5	1.91	5.6
8	10.30	55.0	8.36	25.8	75.1	13.7	2.08	6.4
9	-----	56.1	8.23	25.8	74.7	14.2	2.08	6.5
10	-----	51.1	7.57	25.5	70.6	15.0	2.23	7.5
11	-----	54.0	7.72	28.9	72.7	14.7	2.11	7.9
12	22.00	52.3	7.75	30.8	73.8	13.7	2.03	8.1

[1] Ether extract.

drops. Neither increase nor decrease was at a constant rate but followed trends during which drops and peaks occurred at somewhat regular intervals. The intervals were similar whether the fish were fed or starved, and whether they were held in warmer or colder water (tables 2 and 3).

Protein.--On a wet basis, at both water temperatures, there was a general increase in the percentage of protein in the bodies of the fed trout. There was no statistical difference in the percentage of protein at the two temperatures.

There was a decrease of protein in the starved trout. The decrease was greater in the warmer water than in the colder water.

The changes in percentage of protein in the fish (increases when fed; decreases when starved) were correlated with the increases and decreases of body water. This correlation was most evident in the trout held in the warmer water. These changes in protein and water content were statistically significant.

On a dry basis, the protein apparently decreased in the trout which were fed and increased in the trout which were starved.

Variations within the treatments were too great for measurement of differences, and the apparent differences were not statistically significant.

Fat.--On a wet basis, at both water temperatures, the percentage of fat in the fed trout gradually increased during the first 7 weeks of the experiment, then rapidly increased during the remaining 5 weeks. There was no significant difference in fat content at the two water temperatures. The body fat of the starved fish decreased throughout the experimental period. The decrease of fat was more rapid in the warmer water (1.7 percent fat at the end of 12 weeks) than in the colder water (3.4 percent fat at the end of 12 weeks).

A correlation of the percentage of fat (wet basis) with the percentage of protein (wet basis) indicated that during the last few weeks of the experiment protein was burned for energy by the starved fish held in the warmer water. This correlation was not evident from the body analyses of the fish held in the colder water. It is possible that the low fat content (1.7 percent) of the starved fish in the warmer water represents a physiological minimum under these experimental conditions and the fish must burn protein for maintenance energy.

Ash.--On a wet basis, there was a gradual increase in percentage of ash in the fed fish at both water temperatures. The ash in the starved fish increased at a rapid rate. There was no difference in ash content at either water temperature.

On a dry basis, the starved trout contained high percentages of ash, which apparently increased as fat was metabolically removed from the body. The apparent increase reflects an increase of one component as another decreases.

TABLE 3.--Percent mortality in trout starved and fed in water at temperatures of 47° and 58° F.

Treatment	Percent mortality at end of 10 weeks	11 weeks	12 weeks
Starvation in water at 47° F.	1.2	1.3	2.6
Feeding in water at 47° F.	.0	.0	.0
Starvation in water at 58° F.	7.0	12.4	17.7
Feeding in water at 58° F.	.0	.0	.0

Discussion

Significant changes occurred in the chemical composition of the starved or fed trout over a 12-week experimental period.

The trends of chemical changes in the bodies of the starved fish were similar at the two water temperatures, but the percentage changes in body composition were greater in the warmer water. These differences may be expected because of the greater metabolic rate of fish held in warmer water.

The groups of fed trout held in the different water temperatures were similar in body composition throughout the 12-week period. The food consumed by the fish must be utilized for similar purposes and at similar percentage rates for the various body functions regardless of water temperature. These results support in part the previously reported conclusion that the number of calories and grams of protein required to produce a pound of trout appear to be independent of water temperature (Phillips et al. 1957).

It is generally accepted that in warm-blooded animals, over a limited range, body metabolism increases by 10 percent for each degree Centigrade rise in body temperature (Sumner 1927). Sumner did not use a compound-interest equation in calculating total percentage changes in metabolism.

If Sumner's relationship holds for fish, the body metabolism of trout held in 58° F. (14.4° C.) water was 62 percent greater than that of fish held in 47° F. (8.2° C.) water. If growth or weight losses are valid estimates of metabolic rates, then the gains or losses of fish held in 58° F.

water should differ by 62 percent from those of fish held in 47° F. water.

The periodic weights of the fish used in these experiments are shown in tables 1 and 2. If the weights of the fish held in 47° F. water are taken as a standard for comparison, it should be possible to estimate the expected weights of fish either fed or starved in 58° F. water. These estimates are shown in table 4.

The estimated and actual weights of the starved fish for the three time intervals are in reasonable agreement. For all practical purposes, total catabolic metabolism of a "captive" food supply is measured during starvation. The anabolic metabolism necessary to maintain life during starvation must result from the utilization of stored body materials, and in this sense the activity may be considered catabolic in terms of body tissues. Under these conditions Sumner's rule of 10 percent may be applied directly to our experimental results, and the metabolism of the trout's body does indeed increase 10 percent for each degree Centigrade rise in body temperature.

When the fish are fed, deviation of actual from estimated weight increases with time and it is not possible to estimate weight of fish by the 10-percent method. Simple maintenance metabolism is not measured during feeding because new tissue (growth) is laid down, formed from an external food supply. The rate of gain of the fish is on the same basis as the calculations for compound interest, and the total percentage of gain over the 4-week weighing intervals of these experiments exceeds the postulated 10-percent increase in metabolism.

The total percentage of gain of the fed fish in 58° F. water (850) is approximately 2.5 times that of fish fed in 47° F. water (300). The total percentage of loss of the starved fish in 58° F. water (31) is less than twice that of starved fish held in 47° F. water (20). The difference in weight loss between the two groups of starved fish agrees well with the postulated increase of 62 percent in metabolic activity of the fish held in the warmer water. No such correlation can be shown for the total gains of the fed trout.

During the experiment, the fish held at 58° F. were exposed to 2,184 temperature units (Wallich 1901) and those held at 47° F. were exposed to 1,260 units. The fish held in the warmer water were exposed to 58 percent more units than those in the colder water. The 58 percent agrees reasonably well with the calculated difference of 62 percent in metabolism and the actual difference of 65 percent in the weight loss of the starved fish.

The calculations of percent differences in metabolic activity and the temperature units to which the experimental fish were exposed are subject to the unavoidable inaccuracies of the measurement of water temperature. The temperature of the warm water supply used by the hatchery fluctuates daily, and it is almost impossible to estimate an accurate average value. Such inaccuracies affect the

TABLE 4.--Comparison of weights of fish starved and fed in water at temperatures of 47° and 58° F.

Time (weeks)	Actual weight of fish held in water at 47° F. (grams)	Weight of fish held in water at 58° F. Actual (grams)	Weight of fish held in water at 58° F. Estimated (grams)	Difference
		Trout starved		
0	2.31	2.31	-----	------
4	1.96	1.77	1.75	+ 0.02
8	1.90	1.74	1.65	+ .09
12	1.85	1.60	1.57	+ .03
		Trout fed		
0	2.31	2.31	-----	------
4	3.73	5.10	4.61	+ 0.49
8	6.05	10.30	8.37	+ 1.93
12	9.30	22.00	13.65	+ 8.35

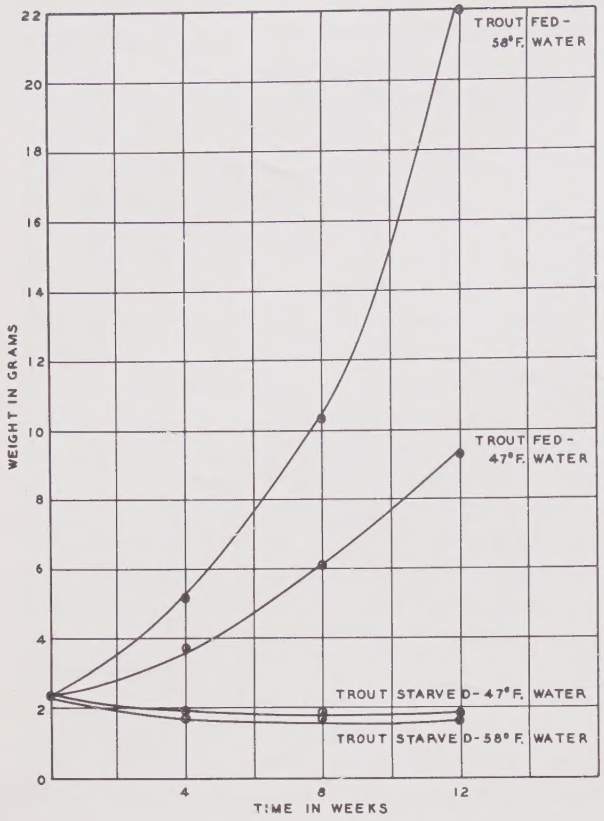

FIGURE 1.--Effect of starvation and feeding on average weight of brook trout held in water temperatures of 47° and 58° F.

calculations of true values for metabolic changes or temperature units.

Of the components studied, only the fat of the fed fish increased to a major extent during the 12-week period. The data indicate that fat was deposited at the expense of water. There was a slight increase in protein (wet basis); but as the protein decreased slightly on a dry basis, the wet-basis increase was a reflection of changes in the water content of the body.

The fish used in these experiments were small (2.31 grams), and the period covered by these studies was one of rapid growth (figure 1).

Changes in body composition of fed fish were correlated with time rather than size or water temperature.

Changes in body composition of starved trout were correlated with both time and temperature. The changes were more rapid in the warmer water than in the colder water. The mortality rate was highest in the fish that were held in the 58° F. water. At the end of 12 weeks, starved fish held in 47° F. water were dying at a rate about one-eighth that of fish held in 58° F. water. Over the 12-week period, the general decrease in protein of fish held in the warmer water indicated that these starved fish were burning protein for energy. No such evidence was found in the fish starved in the colder water. Perhaps this difference in metabolic activity explains the lower mortality rate of the fish starved in 47° F. water.

The changes in the protein content, whether these trout were starved or fed and whether they were held in warmer or colder water, followed the rhythmic changes in the water content of the trout body (figures 2 and 3). The apparent regularity of these changes is difficult to explain. The changes in water content, and hence the changes in protein content, occurred at approximately the same time regardless of experimental variables. Possibly the peaks in water content are correlated with phases of metabolism that occur independently of nutrition and water temperature. As the water content increases, the percentage of protein decreases. As the metabolic activities progress, adjustments may become necessary; and as the water content decreases through elimination, the percentage of protein increases. It is also possible that the rhythmic changes are more apparent than real, and that some inherent experimental error is responsible for them. As they do occur at both water temperatures, whether the fish are starved or fed, they cannot be ignored.

In fed trout, fat increased at a constant but relatively slow rate in the first 7 weeks and at a rapid rate in the last 5 weeks (figures 2 and 3). Similar patterns of fat changes occurred in trout fed at either water temperature. There is no statistical difference in the percentage of fat in the bodies of either group. The

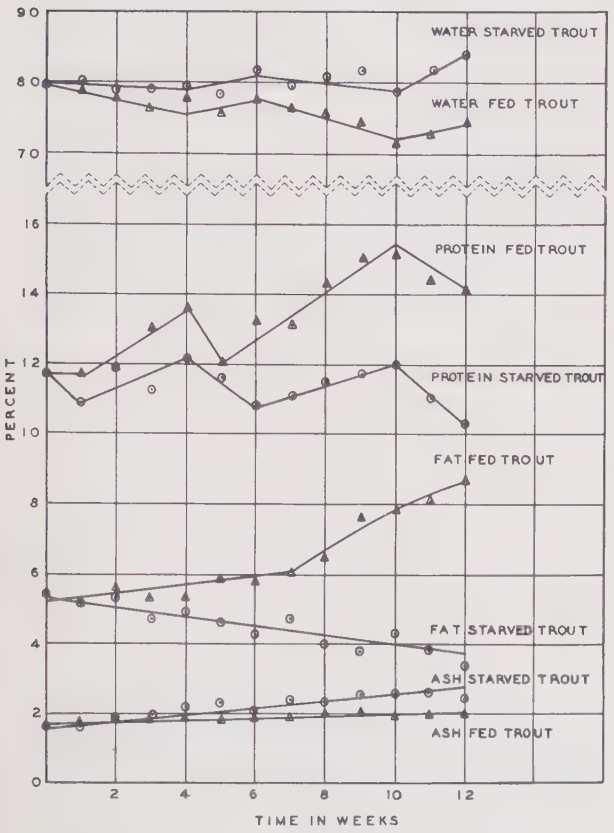

FIGURE 2.--Effect of starvation and feeding on body chemistry of brook trout held in 47° F. water over a 12-week period.

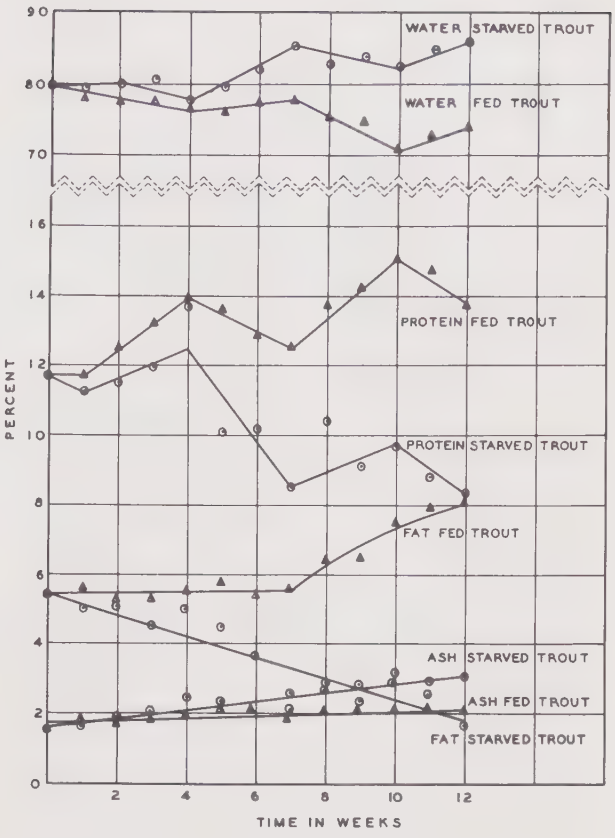

FIGURE 3.--Effect of starvation and feeding on body chemistry of brook trout held in 58° F. water over a 12-week period.

shift in rate of fat deposition that occurred at the end of the seventh week must represent some changes in metabolic activity within the body. As the changes occurred independently of water temperature and were correlated with time, it is possible that they resulted from some metabolic cycle yet undescribed. Seasonable metabolic cycles in higher animals have been described, and Shell (unpublished[3/]) has discussed evidence indicating that bass may pass through rhythmic changes of metabolism.

There is no difference in either the pattern of fat deposition or the amount of fat deposited at the two water temperatures. Fish size is not a factor, because, by the end of the experimental period, the fish held in the colder water were less than half the size of those held in the warmer water.

It is startling to find these changes in rapidly growing fish over such a short period of time; if the analyses had not been made at weekly intervals during this period, the changes might not have been observed. The summer period covered by these experiments is considered a period of rapid growth, characterized by a continuous, relatively smooth growth rate (figure 1). The growth rates plotted for these experiments provide a false impression of metabolism, as chemical analyses indicate that metabolism was not occurring at a smooth and continuous rate.

[3/] Shell, Eddie Wayne. Chemical composition of the blood of smallmouth bass. Ph.D. thesis. Cornell University, Ithaca, New York. 1959.

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A FIBERGLAS RAFT FOR GROWING OYSTERS OFF THE BOTTOM

During studies on the growth of oysters off the bottom, a Fiberglas raft was designed and built to support the weight of 25 bushels of marketable oysters. This raft is a rectangular box with horizontal wings on each long side. The box is 12-1/2 feet long, 16 inches wide, and 8 inches high. The wings are 12-1/2 feet long, 10 inches wide, and 1/8 inch thick. Each wing has two rows of holes (5/16 inch in diameter, 4 inches apart). Nylon and plastic strings with experimental oysters attached are hung from these holes. A hole 1 inch in diameter is drilled at each end for the attachment of a mooring line. Total cost of the raft was $225.

The raft weighs about 70 pounds and can easily be carried by two men. It is so designed that either the top or the bottom can rest in the water. Annually the raft is turned over and all fouling organisms are scraped off.

The Fiberglas raft has been moored in 10 feet of water at Taylors Pond, South Chatham, Massachusetts, since August 18, 1958. During this time it has been subjected to strong winds and winter icing without any damaging effects to the structure. To date, use of the raft has proved successful as a method of growing oysters off the bottom.

--WILLIAM N. SHAW, Bureau of Commercial Fisheries, Woods Hole, Massachusetts.

SOME EFFECTS OF TEMPERATURE ON THE METABOLISM AND ACTIVITY OF THE LARGEMOUTH BASS, *MICROPTERUS SALMOIDES* LACEPEDE

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THE LARGEMOUTH BASS, Micropterus salmoides Lacépède, is a species thriving in warmer waters. In ponds of the southern United States, large bass are produced rapidly. Growth is comparatively slow in Ontario ponds, where a lower total heat income affects the pond ecosystem. In these ponds, bass have less to eat and a shorter time to produce flesh from the available food. Temperatures of runoff ponds may reach 21° C. or higher during a period as short as 3 or 4 months in southern Ontario.

In central Alabama, water temperatures of ponds vary between 4° and 13° C. from November 15 to February 15 (Swingle 1952). In Ontario, farm ponds rarely contain water above 4° C. from November to mid-April. Spring and fall seining reveals the sluggishness of bass in cool water. Bass are caught with some difficulty. Remaining at the pond bottom, they are pushed along and often under the seine rather than herded before the net.

Apparently, largemouth bass begin their spawning activities when the water reaches a temperature of 15.5° to 20° C. (Viosca 1937). In summarizing the research of several workers, Davis (1956) stated that bass seldom spawn at temperatures below 18° C., and falling temperatures may cause nest desertion by the males. Swingle and Smith (1943), however, related the physical condition of the fish, and to a lesser extent the water transparency, to the initiation of egg-laying by bass in the Alabama ponds. In northern ponds, spawning activities are often delayed and the period of spawning is limited in comparison to that of southern ponds (Ball and Tait 1952).

Movements of fish are influenced by changes in temperature. Dendy (1946) suggested that warming of deep water of the Norris Reservoir caused an increase in the activity of bass, which then moved into the shallows, apparently in response to the temperature gradient.

To explain some of these responses to temperature, an attempt has been made to measure quantitatively the metabolic rate and activity of a group of largemouth bass fingerlings over a range of temperatures close to those occurring annually in the pond environment.

Activity is a manifestation of energy released by metabolism, but, as Fry (1947) pointed out, measures of activity are not equivalent to measures of metabolism. However, it may be assumed that the metabolism from which the activity results is the difference between the total metabolism and that required as basal metabolism. One estimate of activity of fish may be made by inducing fish to swim at maximum maintained speed. A tube through which a stream of water flows or

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a rotating chamber may be used, while the fish, exhibiting rheotropic response, try to maintain their position with respect to some reference point (Fry 1958). A rotating chamber was used in this experiment.

Metabolism may be expressed as oxygen uptake. Two levels may be studied: First, that of the resting fish; and second, that of the fish at the maximum activity possible under the environmental conditions obtaining at the time. The difference between these two levels has been termed appropriately "the scope for activity" (Fry 1947). The scope for activity is subject to change with the action of many factors on either level of metabolism. It should be pointed out that the standard metabolic rate is not the true basal, and the active also includes the extra cost of ancillary activities maintaining the activity under consideration. However, the scope curve was originally established for relation to activity and has been used most frequently for that purpose.

As well as cruising speed and standard and active oxygen uptake, the food consumption was measured when food was offered in unlimited supply.

The criteria previously described were used in this experiment to facilitate their comparison with regard to the effect of temperature on each.

Materials and Methods

The largemouth bass used in the experiment were fingerlings approximately 8 months of age. Their weights ranged from 6 to 10 grams (average, 7.8 grams); their lengths ranged from 83 to 97 millimeters (average, 87 millimeters). The bass were produced in a farm pond near Woodbridge, Ontario, from parent fish of Lake Scugog origin. The fingerlings were received at the laboratory in November 1959 and were held at 10° C. until the experiment was begun the following January.

Four fish were placed in each of three aquaria. The aquaria were placed in a single large hatchery tank which served as a controlled-temperature bath. Through aeration, the dissolved-oxygen concentration was maintained near saturation. To simulate the thermal changes which occur in pond waters from late winter to summer, the temperature of the unit was raised 5° C. each week, beginning with the temperature 10° C. Electric heaters were used in conjunction with a flow of tap water (10° C.) to regulate the desired temperature increase. Some fluctuation occurred, principally because of variations in water pressure within the building.

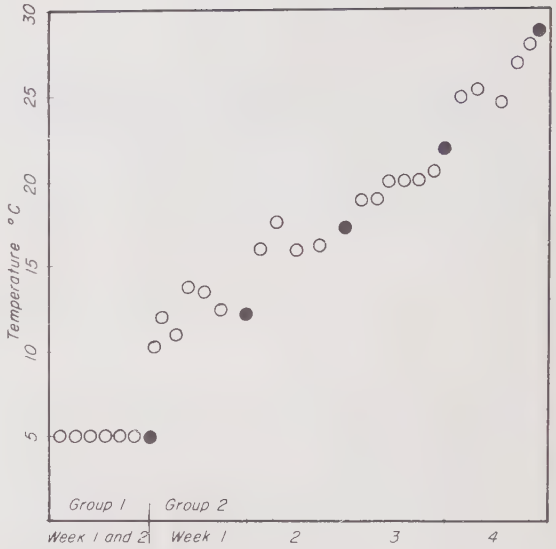

FIGURE 1.--Daily temperatures of the test fish. (Open circles are temperatures recorded between selected weekly experiments; solid circles are the temperatures which occurred on the day of each experiment, therefore the acclimation temperatures used in the study.)

One group of three fish was placed in a cold storage room at a temperature of 5° C. These fish were given 2 weeks to become acclimated before observations were made. Thermal histories of the two groups (water-bath and cold-room) during the test period are shown in figure 1.

At the termination of each week the following measurements were made:

A. Cruising Speed

The apparatus used in measuring the cruising speed of the test fish was similar

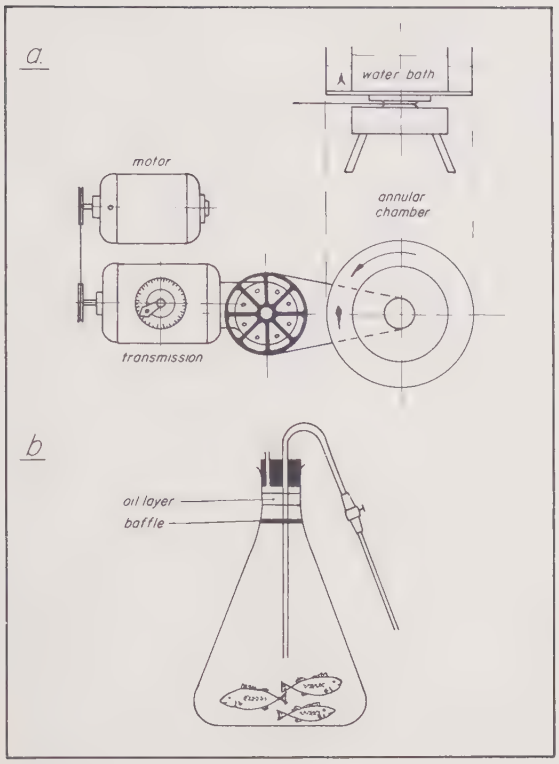

FIGURE 2.--Apparatus used in the study to determine oxygen uptake and cruising speed.

to that described by Fry and Hart (1948). An annular chamber, with inside diameter of 30 centimeters and outside diameter of 50 centimeters, was mounted on a turntable which could be rotated by an electric motor operating through a variable-speed transmission (figure 2: a).

Ten liters of aerated water were placed in the chamber. The inner bowl of the apparatus served as a water bath to maintain the desired temperature. The cruising speeds of six fish were measured at each acclimation temperature. Fish were introduced into the chamber singly. The chamber was rotated slowly until the fish showed a response by maintaining its position in the shaded area opposite a 60-watt bulb mounted nearby. The speed of rotation was increased in small increments. At each speed of the chamber, the revolutions were measured during the first minute. During the first and the second minutes the number of revolutions which the fish lost was noted. If the fish did not lose a single revolution during the 2-minute period, the speed of the chamber was increased slightly and the process repeated.

The performance or cruising speed of each fish was calculated as follows. If a fish lost one revolution or more during the first minute, the speed previously and successfully negotiated was noted as the cruising speed. If the fish maintained its position during the first minute and lost one revolution or more during the second minute, a compromise was made between the speed in question and the previous speed. For each revolution lost during the second minute, one-half revolution was deducted from the higher speed and the result was recorded as the cruising speed.

B. Standard Metabolic Rate

The oxygen consumption of resting fish was measured as an estimate of the standard metabolic rate. Three fish were used in each determination. The fish were placed in a 2-liter flask. Evidently the handling of fish raises their oxygen consumption above the resting level, and the excited condition may persist even though the fish show no signs of activity (Graham 1949). Therefore, the bass were placed in the flask 1 day prior to testing. The flask was wrapped in aluminum foil to exclude light. Oxygen was supplied through a delivery tube later used to draw off water samples for the determination of dissolved oxygen. The apparatus is shown (figure 2: b).

After 24 hours, aeration was stopped and a layer of paraffin oil was applied to the surface of the water in the neck of the flask to serve as an air seal. A baffle prevented the fish from disturbing the layer of oil. A sample was then drawn off, and the oxygen content was determined by using the unmodified Winkler method. The initial level of oxygen varied from 80 percent to 115 percent of saturation for the analyses made at different

acclimation temperatures. From less than 1 to more than 3 hours later, depending on the temperature and expected utilization, a second sample was removed and analyzed. Usually the level of oxygen had dropped to 40 percent saturation during the interval. The volume of oxygen utilized was then calculated.

C. Active Metabolic Rate

Three fish were placed in a 4-liter flask of aerated water of the desired temperature. This flask was also fitted with a stopper, delivery tube, and baffle. A layer of paraffin oil was introduced, and a sample was removed for oxygen determination. The flask was then rotated in a water bath on a turntable to produce within the flask a current equal to the cruising speed recorded in section (a) for the temperature in question. Generally the fish responded to the current by maintaining their position near the perimeter of the flask, but occasionally one or more fish would retire to the central or upper waters within the flask. After 0.5 to 3 hours of rotation, a second sample was removed and the calculation of oxygen utilization made.

The value of this method was checked against the method used by Fry and Hart (1948). Six fish were placed in 10 liters of aerated water (22° C.) in the annular chamber used for the measurement of cruising speed. A layer of paraffin oil was applied, the initial oxygen concentration evaluated, and the chamber rotated at the cruising speed determined previously. From the calculation of uptake it was evident that the method used originally in this experiment underestimated the active metabolic rate by 20 percent. Consequently, at the termination of the original experiment, groups of bass were re-acclimated to the test temperatures and the measurement of active metabolic rate was repeated while using the annular chamber.

One modification of the method outlined by Fry and Hart was made, and that was in the use of oil as an air seal. Fry and Hart used a floating wood cover, and correction was required for addition of oxygen from the air.

The results of each method of determining the active metabolic rate form characteristically similar relationships to temperature, but only data from the final method are used further in this study.

D. Food Consumption

At the beginning of each week, 12 minnows (Notropis cornutus and Pimephales promelas) were added to each aquarium. The number of minnows was maintained at 12, and consumption was totaled during each week.

Minnows of a limited size only were provided to facilitate the comparison of food consumption at different temperatures. Minnows which could not be taken by the bass were not offered. The upper limit of acceptable size was determined by providing a group of fish of wide range in size. Those that remained were measured when the bass had ceased to feed for 1 day. Minnows up to 65 percent of the average length of the bass were taken.

The weekly utilization of minnows is assumed to indicate the rate of food consumption at the mean temperature for each week. Consumption by the bass in each aquarium might have been influenced by the numbers of minnows utilized during the previous week. However, the mean value of three replicates should lack this bias.

Results

A. The Effect of Temperature on Cruising Speed

Cruising speeds for six fish at each of the acclimation temperatures were averaged and tabulated (table 1).

The bass acclimated to 5° C. were slow to respond to even a slight current. Only after some stimulation with a glass rod would they move off the bottom of the tank to swim, and then only a very slow cruising speed could be maintained.

It was noted that at the maximum cruising speed at each acclimation temperature

TABLE 1.-- Standard and active oxygen consumption and cruising speed observed in largemouth bass fingerlings at several temperatures to which the fish were acclimated

Acclimation temperature (°C.)	Standard oxygen uptake (c.c./kg./hr.)	Active oxygen uptake (c.c./kg./hr.)	Cruising speed (ft./min.)
5	38	48	19
12	130	198	44
17	134	250	48
22	185	303	82
29	320	450	80

the fish moved closer to the outside wall of the annular chamber. Apparently at this speed the fish had difficulty in maintaining their position between the walls of the chamber; that is, against the centrifugal thrust.

A slightly lower cruising speed was recorded at 29° C. than was noted at 22° C. At temperatures below 22° C., the relation of cruising speed to water temperature appeared to be linear (figure 3).

B. The Effect of Temperature on Metabolism

The relation between temperature and standard metabolism is characteristically similar to the relation found in other fish species by other workers. Diurnal fluctuations have been shown in the standard metabolism of several species. Although the test fish were held in darkness for 24 hours before determination of oxygen uptake, it is possible that a slightly lower curve of standard metabolism could have been produced. The observations were made, however, consistently during the midafternoon.

The rate of active metabolism has formed an approximately linear relation to temperature through the temperature range used in the experiment. Evidently the active metabolism did not level off at the highest test temperature (29° C.).

To ensure that the effect of temperature on metabolic rate was adequately measured, oxygen could not be allowed to act as a controlling or limiting factor. In this experiment, in which initial oxygen concentrations were high and utilization periods were relatively short, it is proposed that temperature was the only important environmental factor varied.

These data have been listed in table 1 and plotted in figure 4. The scope for activity has been plotted in figure 4 (lower panel) as the difference between the standard and active values obtained at the five test temperatures.

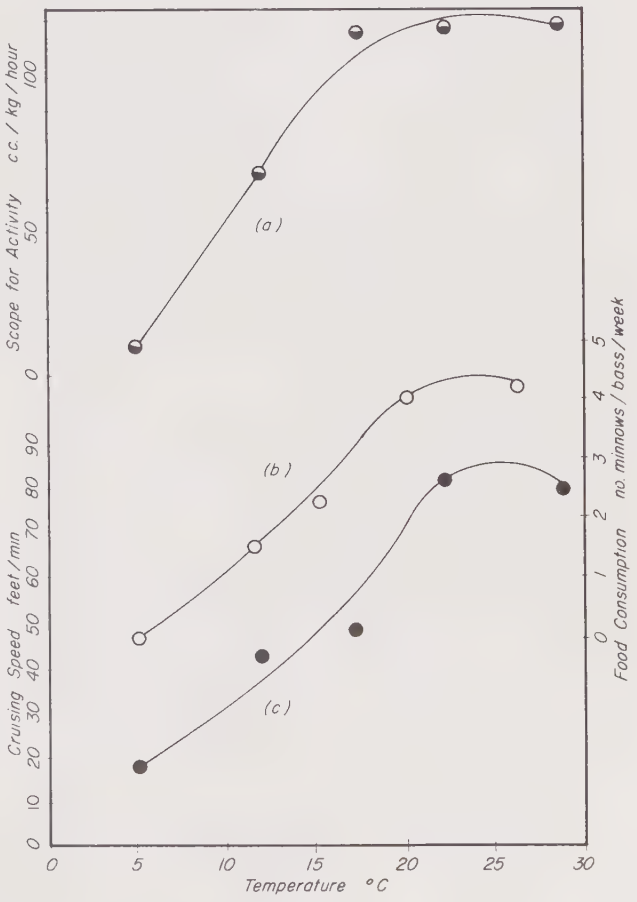

FIGURE 3.--The scope for activity (a), food consumption (b), and cruising speed (c) of largemouth bass at several experimental temperatures.

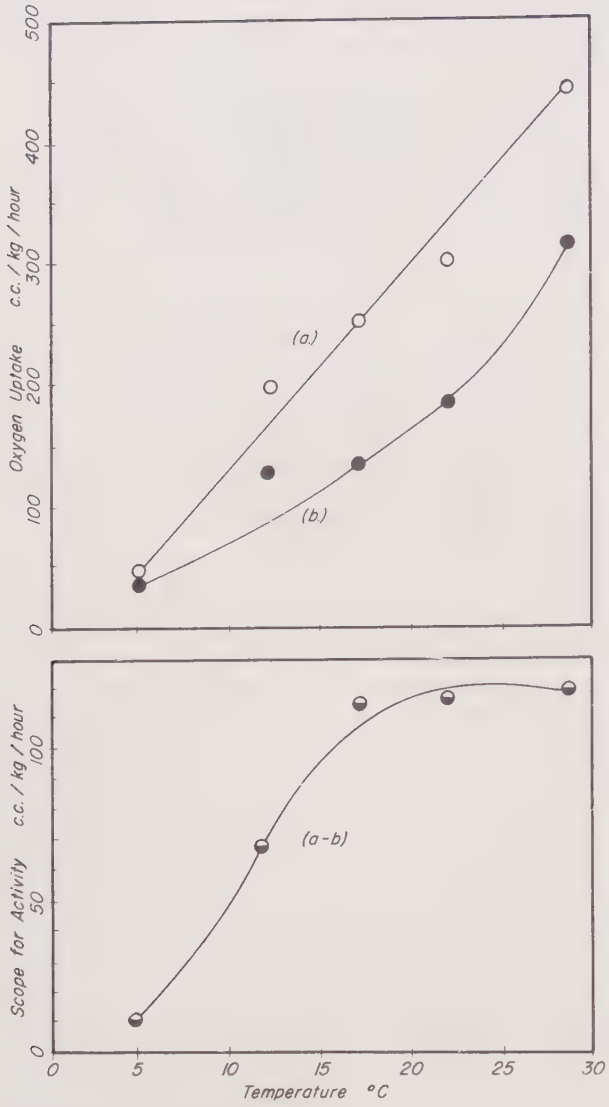

FIGURE 4.--The standard metabolic rate (b), active metabolic rate (a), and scope for activity (a-b) of largemouth bass held at several experimental temperatures. The utilization of oxygen was derived from its reduction from approximately 100 percent to 40 percent saturation by groups of test fish in a closed system.

C. The Effect of Temperature on Food Consumption

A continuous supply of minnows of a narrow range in size was provided. The numbers of minnows consumed (per bass per week) are listed with weekly mean temperatures in table 2 and plotted in figure 3.

Discussion

The absolute rate of standard metabolism increased throughout the range, although the proportional rate decreased. Fry (1947) stated that temperature allows the highest standard metabolic rate at a level which is very close to the incipient upper lethal level. For largemouth bass from Put-in-Bay, Ohio, acclimated to 30° C., Hart (1952) found this level to be 36° C. Hathaway (1927) observed an upper lethal level of 35° C. in bass from Lake Mendota, Wisconsin, also acclimated to 30° C. Although the temperature range of the largemouth bass was not sampled completely in this experiment, it is safely assumed that the rate of standard metabolism would have continued to increase up to the upper lethal temperature.

The active rate showed a greater slope than the standard at lower temperatures. However, inflection of the standard curve at higher temperature absorbed a progressively greater portion of the total metabolic capacity. In many species the active rate drops with increasing temperature at a point well below the upper lethal level. That this is not typical of all species is evidenced by the data of Paul and Fry (Fry 1947) for the bullhead, in which species the active rate continued to increase up to the upper lethal temperature. Regardless of whether the active rate of the bass had been depressed above 30° C., inflection of the standard rate would have brought the two curves into closer proximity with rising temperature.

The relation between temperature and cruising speed (figure 3) supports the value of the scope-for-activity curve. For practical purposes the scope and cruising-speed curves can be described as rising steadily from 5° C. to level off over the range 22° to 29° C. Scope and cruising-speed curves characteristically lack sharp inflections. Therefore, it is possible to detect the region of a peak by interpolation, though it is much more difficult and probably of less significance to establish

TABLE 2.--Weekly consumption of food observed in largemouth bass fingerlings

Weekly mean temperature (°C.)	Food consumed (minnows/aquarium group/week)	Food consumed (minnows/bass/week)
5	0	0.0
12	9, 3, 7	1.6
17	10, 6, 12	2.3
20	14, 20, 15	4.1
27	17, 9, 25	4.3

the magnitude of the peak. Probably the cruising speed reached a maximum in the vicinity of 25° C.

It has been stated that the maximum cruising speed increases with acclimation temperature to a peak at the final preferendum (Fry 1947, Sullivan 1954). The final preferendum is the temperature which all fish eventually will select regardless of their thermal history. This coincidence of the values has not always occurred in separate studies on activity and temperature selection. For example, the maximum cruising speed of the goldfish was indicated as approximately 25° C. (Fry and Hart 1948), but the final preferendum was 32° C. (Pitt, Garside, and Hepburn, 1956). The final preferendum of bass was given as 30° to 32° C. (Ferguson 1958, as cited by Fry[1/]), several degrees above the temperature of maximum cruising speed indicated in this study. Field observation on the preferred temperature of largemouth bass indicated selection of water at 26.6° to 27.7° C. in the Norris Reservoir (Dendy 1948).

In comparing cruising speed and scope for activity, it is important to appreciate that performance is not derived from power in any simple relation. Thus the speed of an automobile is not directly proportional to the fuel consumed. Figure 3 shows that here the power required (scope) increased more rapidly than the performance (cruising speed). From 5° to 25° C., the latter being the point at which additional power was unavailable for further increase of performance, a 12-fold increase in scope produced a 4-fold increase in cruising speed. A square-root plot of scope generally has been used to present this relation graphically.

The question arises whether to attempt a comparison of food utilization with the active metabolic rate or scope for activity. Presumably the bass held in aquaria are reasonably active and require a food supply to satisfy total metabolism; yet the capture and consumption of prey form an activity which is governed by power available beyond that required for basal metabolism. The curve of food consumption resembles that of scope for activity in leveling off at higher temperatures, although the active metabolic rate continued to increase. It is possible that the active rate might have leveled off between 30° C. and the upper lethal level. Nevertheless, this experiment indicated that the proportional rate of increase in the rate of food consumption of the test fish was decreased by a similar change in the power (scope) available, in spite of a steady increase in total metabolism.

Little scope for activity was shown at the lowest temperature. Bass at 5° C. responded to a current with some difficulty; but once stimulated to swim when prodded with a glass rod, they were able to maintain a cruising speed of 19 feet per minute. The fish were never observed above the floor of the aquarium. They could be picked up and handled with little response being shown. As may be seen in figure 3 (c), they did not eat at 5° C. It was thought that the minnows offered might be too large for the bass at the low temperature, but even very small minnows were ignored. The minnows appeared more active than the bass. Possibly the bass could utilize less mobile prey in cold waters. The maintenance of equilibrium appeared somewhat hampered. A fish that was purposely tipped on its side regained normal position after several seconds.

[1/] Fry, F. E. J. Temperature preference and cruising speed of largemouth and smallmouth bass in relation to acclimation temperature. (Manuscript, 1950)

The low scope for activity at a low temperature, as indicated visually by sluggishness and the failure to feed, may be an asset to largemouth bass under certain circumstances, particularly where oxygen concentrations of pond waters drop precipitously during the late winter. The oxygen requirements for maintenance may be as low as 10 percent of the requirements at 29° C. (figure 4); but, more important, the fish cannot become any more than slightly active. Fry (1947) proposed that when a limiting factor (in this case, oxygen) is operating, the stress is posed by the organism itself, for if the organism remained completely quiescent, it would not be affected by the factor in question. However, this would not apply when the level was so near the lethal that considerable effort would be required to meet maintenance requirements. Apparently the stress is occasioned by the activity of the animal in response to the stimuli of its environment. Therefore, oxygen depletion at higher temperatures would pose a more serious threat to the bass, not only because of their higher requirement for basal metabolism, but also in regard to Fry's explanation of stress imposed by a limiting factor (in this case, oxygen) but accompanied by high temperature as a stimulus toward a high state of activity.

Denyes and Joseph (1956) found that an average opercular pulse rate of 16 per minute at colder temperatures (5° to 10° C.) was sufficient to load the hemoglobin with as much oxygen as could be loaded at higher temperatures (32° to 35° C.) with a 5-fold increase in opercular pulse rate.

No account of the progress of egg development in the northern female bass was found. In Alabama, the development of the eggs starts as early as September and continues during the winter and early spring months (Swingle and Smith 1943). It is conceivable that little egg development would take place in pond waters having temperatures of 0° to 2° C. This would increase the amount of time required after breakup before egg-laying was initiated.

No information on the feeding habits of the largemouth bass during the period of ice cover was found. Largemouth bass are caught occasionally by ice-fishermen at Frenchman Bay, east of Toronto. Whether the fish are captured through actual feeding efforts is open to question, although water temperatures of Frenchman Bay do not become so cold throughout as temperatures in most farm ponds (Johnson, unpublished data).

At higher temperatures the scope for activity and cruising speed show little proportionate increase. As mentioned previously, the final preferendum is given as 30° to 32° C., though Denyes and Joseph (1956) made these observations. When the waters of Lake Opinicon (Florida) reached 28° to 30° C. during a period in August, largemouth bass remained quietly in the shade of overhanging trees along rocky shores or under masses of water lilies. Their stomachs were empty, and the fish were difficult to catch by line and bait. At that time the bass revealed that they had reached a state close to their physiological limit. At temperatures of 28° to 30° C., loading at the gills was difficult. The reduced metabolism through quiescence and starvation helped to maintain a precarious existence. Laboratory experiments confirmed these observations. Presumably the cessation of feeding and the reduction in activity indicated a depression in the scope for activity of the Florida fish, a condition which occurred at a similar temperature in the fish of this study.

Acknowledgments

The authors wish to acknowledge the guidance of Dr. H. R. McCrimmon and Mr. A. H. Berst of the Department of Entomology and Zoology. The Fish Culture and Diseases Research Unit operated by the aforementioned department and the Department of Microbiology of the Ontario Agricultural College provided facilities. The Metropolitan Toronto and Region Conservation Authority provided the bass and additional equipment.

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METHODS FOR ROUTINE FISH HEMATOLOGY

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IN HUMAN MEDICINE, HEMATOLOGY is one of the most reliable tools in the hands of the clinician. There appears to be no reason why fish hematology should not be equally effective as an aid in the diagnosis of fish diseases. However, without definite knowledge of what is normal, it is difficult to differentiate between the normal and the pathological state of fish. There is available a considerable amount of literature covering the field of teleost hematology. However, only scattered reports (Watson 1956; Katz, unpublished,[1/] 1950) have appeared on the subject of salmon hematology. Obviously, a well-rounded fishery research program should include a more extensive study of the hematology of salmonids. Therefore, techniques suitable for the identification and enumeration of the cellular constituents of fish blood have been tested and adopted from general hematology methods. Use of these methods should establish the limits of certain hematological factors to serve as reference values for future work in fish pathology.

Blood Collection

Numerous techniques have been devised in the past for collecting blood samples from various sizes of fish (McCay 1929; Root 1931; Dawson 1935; Field, Elvehjem, and Juday, 1943; and Yokoyama, unpublished[2/]). The cardiac puncture, venous puncture, and severance of the caudal peduncle have been commonly used procedures. Larger fish can be anesthetized and blood drawn directly from the heart or from the dorsal aorta (Schiffman 1959). This allows repetitive sampling of the same fish. With fish less than 6 inches in length, severance of the caudal peduncle has proved most feasible. This procedure circumvents the problem of rapid clotting, because the exposure to air is reduced to a minimum as the blood is drawn immediately into the pipette and/or hematocrit tube.

Anticoagulants

Various anticoagulants have been employed to prevent coagulation of fish blood. McCay (1929) placed mineral oil in the syringes and needles, and crystals of oxalates or citrates in the centrifuge tube; Schlicher (1927) injected 5 percent ammonium oxalate a few minutes before bleeding the fish; Duthie (1939) coated the containers with wax; Field, Elvehjem, and Juday (1943) employed 0.1 M sodium oxalate or heparin in the syringe; Wintrobe (1934) and Yokoyama (unpublished[2/]) preferred heparin as the anticoagulant. Heparin (0.4 to 0.6 milligram per milliliter

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[2/] Yokoyama, Hisado Ogawa. Studies on the origin, development, and seasonal variations in the blood cells of the perch, Perca flavescens. Ph.D. thesis, University of Wisconsin, Madison, Wisconsin. 1947.

of blood) has proved to be the most satisfactory anticoagulant at this laboratory. With this compound, crenation and/or lysis of the erythrocytes is minimal. However, ethylenediaminetetracetic acid (EDTA) salts, ammonium and potassium oxalate and citrates may also be used as anticoagulants with fair results. The oxalates produced some crenation of the cells when used individually or in combination.

EDTA salts are less likely than the oxalates to produce crenation of the cells and are therefore indicated if heparin is not available. When using heparin, it was found necessary to use 2 drops per 5 milliliters of fish blood rather than the recommended 1 drop per 5 milliliters for mammalian blood. For small quantities of blood, this will produce a significant dilution factor. Therefore, if anticoagulants are to be used for 1 milliliter of blood or less, a hypodermic syringe coated with heparin and dried will produce good results without an appreciable dilution factor. Blood should be mixed thoroughly but gently with the anticoagulant; excessive agitation will cause undue hemolysis. A gentle swirling action or up-and-down motion for just a few seconds is sufficient for mixing. Excessive pressure should be avoided when drawing or expressing blood through the needle to prevent lysis of the cells.

Erythrocytes

The erythrocytes of fish blood, like the mammalian counterparts, contain hemoglobin and thus are active in the transport of oxygen to all tissues and organs of the body. Again, as in the mammal, there is possible evidence that abnormal levels and forms of erythrocytes are associated with pathology.

The techniques of erythrocyte counts of fish blood are similar in most respects to those used in mammalian counts. However, the diluting fluids normally used for mammalian counts were not applicable to fish bloods. Gower's and Hayme's diluting solutions were not usable because the cells became distorted after a few minutes. Hendricks (1952), in a study of the blood of suckers (Catostomus), developed a diluting solution which circumvents the foregoing problem and which has proved quite satisfactory in the study of salmonid bloods. Hendricks' diluting solution was prepared as follows:

Sodium sulfate----------	10.0 gms.
Sodium chloride----------	2.5 gms.
Sodium citrate----------	1.5 gms.
Glacial acetic acid------	50.0 mls.
Water to make 500 mls.	

The standard RBC diluting pipette and a 1:200 dilution were used for the erythrocyte count. Blood was drawn just beyond the 0.5 mark on the pipette. The tip of the pipette was wiped with a soft absorbent tissue to adjust the volume to exactly the 0.5 mark (figure 1: 2). The pipette was immediately filled to the 101 mark with the diluting fluid (figure 2: 2). Partial rotation of the pipette while it was being filled assured the complete mixing of the blood and diluting fluid and prevented clotting. With its ends grasped between the thumb and second finger, the pipette was then shaken for 30 to 60 seconds. (A shaking machine was also available for this purpose.) After the pipette had been shaken, a few drops of the diluted blood were expelled from it. Control over the flow of fluid was maintained by placing the index finger over the bulb end of the

FIGURE 1.--Sahli hemoglobin pipette (No. 1) filled to the 20 mm^3 mark. RBC pipette (No. 2) filled to the 0.5 mark. Capillary tube (No. 3) approximately three-quarters full for hematocrit.

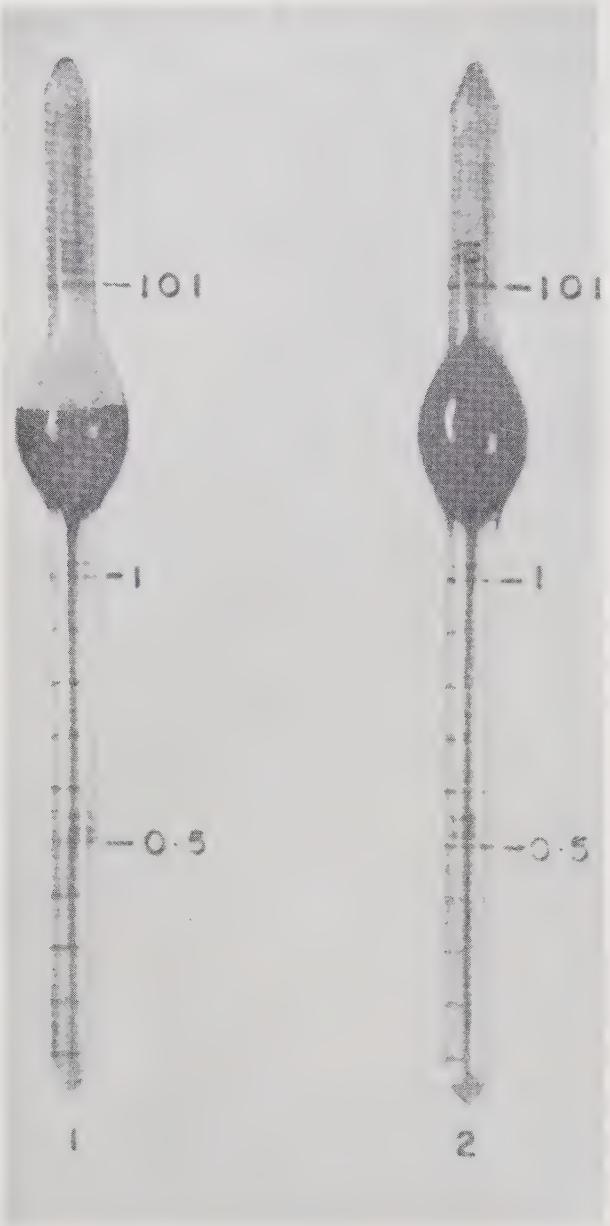

FIGURE 2.--This demonstrates use of Shaw's diluting solution. Blood is drawn to the 0.5 mark, then solution A is taken in to fill bulb approximately half full as in No. 1. Pipette is removed from solution A and filled to the 101 mark (No. 2) from solution B. Hendrick's solution is only one step: fill to 0.5 with blood, and to 101 with the diluting solution.

pipette. The hemocytometer (counting chamber) was either a Neubauer or a Spencer Bright-Line. The pipette was touched to the edge between the cover slip and the chamber, and capillary action drew the diluted suspension of cells into the chamber. The hemocytometer was then placed under the microscope, and the cells were counted. The hemocytometer is divided into ruled areas of 1 square millimeter, with the center square millimeter divided into 25 groups of 16 small squares (figure 3). The cells within the boundaries of five of these small squares were counted. Each corner plus the center group should be counted. When the erythrocyte count was computed, the number of cells counted in all five squares was multiplied by 10^6. This gave the total number of cells per cubic millimeter of blood.

Leukocytes

In human hematology, diluting solutions which lyse the erythrocytes are used. With fish blood this is not possible, as the erythrocytes are also nucleated.

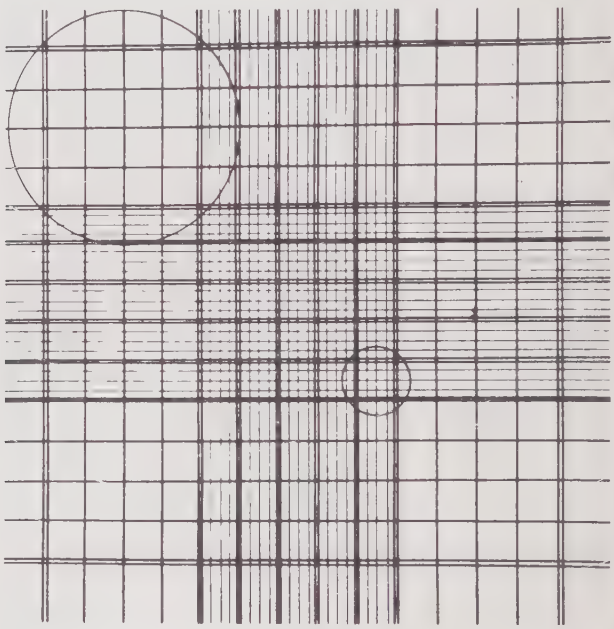

FIGURE 3.--Ruled lines on the hemocytometer counting chamber. The small circle takes in one of the five squares to be counted for total RBC (this includes the four outside plus the center square, the total count x 10^6). The large circle encloses one of the four squares to be counted for total leukocytes (total of four squares x 500).

Yokoyama (unpublished[3]) developed a diluting solution incorporating specific aniline dyes and was able to enumerate the types of cells present as well as the stages of maturity. Katz (unpublished[4]) also employed the Yokoyama technique but found a somewhat different reaction with salmon blood, although he obtained satisfactory results. At this laboratory, however, difficulty was encountered in differentiating between types of cells. Furthermore, the stain precipitated in the pipettes within 5 to 10 minutes, and this precluded the counting of the cells.

A staining solution developed for the counting of avian leukocytes (Shaw 1930) was investigated. By using Shaw's solution, the differentiation between leukocytes, erythrocytes, and thrombocytes was readily made. Shaw's counting fluid was prepared as follows:

Solution A	
Neutral red----------	25.0 mgs.
Sodium chloride-------	.9 gm.
Distilled water-------	100.0 mls.

Solution B	
Crystal violet--------	12.0 mgs.
Sodium citrate--------	3.8 gms.
Formaldehyde----------	.4 ml.
Distilled water-------	100.0 mls.

Both solutions were filtered just prior to use. Solution A was made up fresh each day; solution B was stable for several days. When leukocyte counts were prepared, the red-cell diluting pipette with a 1:200 dilution factor was used. Blood was drawn up to the 0.5 mark; solution A was added to fill the bulb of the pipette approximately half full, and mixed (figure 2: 1). Next, the pipette was removed from solution A and filled to the 101 mark with solution B (figure 2: 2). The pipette was then shaken as in the erythrocyte count. A few drops were expelled, and the hemocytometer was filled in the manner described previously. For computation of the total number of leukocytes, the cells in the four large squares noted by the large circle in figure 3 were counted. The total number of cells counted was multiplied by 500 to determine the total number of leukocytes per cubic millimeter of blood. This diluting solution made it possible to make erythrocyte and leukocyte counts from the same pipette, saving considerable time by eliminating several steps which are necessary in mammalian hematology. When leukocytes are not counted, Hendricks' diluting solution is preferred.

Hemoglobin

Hemoglobin determination is the quickest means for detecting anemia. However, as many factors are known to influence the hemoglobin level, the conditions under which the hemoglobin determinations are made should be carefully defined, or little reliance can be placed on this test as a parameter for measuring the physiological well-being of fish. Cyanmethemoglobin and 0.1 percent sodium carbonate were not satisfactory for use with fish bloods. When these agents were used, a gelatinous precipitate that formed varied the density of the solution and thus made the colorimetric reading inaccurate. When whole blood was placed in 0.1 N hydrochloric acid, the cells were lysed and the released hemoglobin was converted to acid hematin. A brown color that was produced can be measured photometrically, and its intensity can be plotted against known standards. A detailed description of these methods has been published by Levinson and MacFate (1956). The accuracy of the acid hematin method was affected by several factors, as follows: (1) Time and temperature caused a variation in the rate of conversion to acid hematin, (2) the hematin color was stable for only a short period of time, and (3) lipid content and plasma protein affected the color development. The cumulative effect of these factors produced an error of approximately 0.5 percent (Levinson and MacFate 1956).

The Sahli-Hellige hemoglobin determination was performed as follows: The

[3] See footnote 2, page 164.

[4] See footnote 1, page 164.

Sahli pipette (figure 1: 1) was filled slightly above the 20 mm^3 mark; the pipette was wiped with a soft absorbent tissue to remove excess blood, and the volume was adjusted to exactly 20 mm^3 by blotting the tip. The blood was expelled into a calibrated (transmission) test tube containing 10.0 milliliters of 0.1 N hydrochloric acid, and the pipette was rinsed several times in the acid solution. The sample was allowed to stand for not less than 3 minutes or more than 5 minutes before being read in the colorimeter. The intensity of color was measured at 530 to 540 millimicrons and was recorded either as percent transmission or as optical density. Calibration charts reading grams percent versus percent transmission had been prepared previously (Miale 1958).

Hematocrits

The term "hematocrit" may be defined as the instrument for determining the amount of plasma and corpuscles in the blood and would, in effect, be the measurement of the volume of packed erythrocytes. This could also be defined as the volume occupied by erythrocytes in a given volume of blood, usually measured as the amount of erythrocytes per 100 milliliters of blood.

The limited amount of blood available in small fish necessitated use of a microhematocrit method. However, several advantages accrued to this procedure: (1) Small amounts of blood were required (approximately two drops), (2) heparin-coated capillary tubes were easily filled and were disposable, and (3) centrifuging for 2 to 3 minutes was required, the time depending on the type of centrifuge and speed used. Small capillary tubes, 75 by 0.5 millimeter I.D., are available for fish weighing less than 2 grams. For larger fish, the regular microhematocrit tubes, 75 by 1.2-1.4 millimeter I.D., were used. The tube was touched to the blood sample and filled by capillarity to the three-quarter point (figure 1: 3). The end of the tube was sealed with a commercially prepared plastic and placed in the centrifuge. The tubes were then spun for 3 minutes at 11,500 revolutions per minute, taken from the centrifuge, and placed on a hematocrit computer to determine the volume of packed red cells. This method has proved rapid, effective; it gave values reproducible to $\pm$ 0.21 milliliter per 100 milliliters of blood.

Differential Smears

Differential blood counts are extremely valuable in the hands of the mammalian hematologist, making possible the diagnosis of a wide range of diseases. The term "differential" in this context refers to the difference in the appearance of cells. The cells, as formed by the hemopoietic tissue, show a relatively standard or "normal" distribution. Variations in appearance and variations from the normal frequency distribution can, in many instances, be correlated with specific diseases. For example, monocytic leukemia is a blood disease that is characterized by an increase in the number of the monocytes and variation in their appearance. There seems to be little reason why the differential counts made from fish blood should not produce equal results in diagnosis of a wide variety of physiological conditions both normal and aberrant.

Differential smears were prepared in the following manner. A small drop of blood was placed on one end of a chemically cleaned slide. A second slide was held at an angle of 35° to 40° at about the center of the first slide. The slide was brought back against the blood until it spread by capillarity along the interface between the slides. The slide was then moved (still maintained at an angle of 35° to 40°) in the reverse direction, creating a thin, uniform film of blood on the slide (figure 4). This was air-dried and then fixed in methyl alcohol for 3 to 5 minutes. After being fixed in methyl alcohol, a slide will keep for weeks if necessary before staining.

Several types of stains are available for the preparation of differential smears: Wright's, Kingsley's, Giemsa, Pappenheim's panoptic, and a recent product--

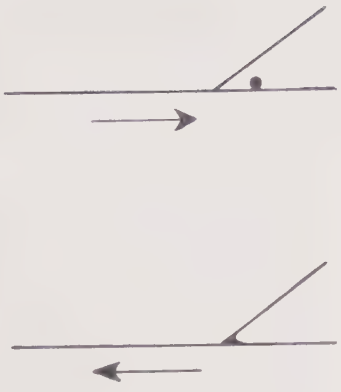

FIGURE 4.--Small drop of blood is placed on end of slide. Second slide, held at 35° to 40° angle, is brought back against the blood; it spreads over the interface of the slide by capillarity. Slide is then moved in opposite direction (holding angle of 35° to 40°), creating a thin film of blood.

Hemal blood stain.[5] Yokoyama (unpublished[6]) employed Wright's, Kingsley's, and Giemsa stain in the preparation of blood slides of perch. Katz, in his studies of silver salmon (unpublished[7]), used Wright's and Giemsa. The nuclear staining properties of Wright's and Giemsa stains were particularly effective for nuclear studies. Kingsley's stain (1935) provided fair nuclear and good cytoplasmic contrasts. The Hemal blood-film stain has been the procedure of choice at this laboratory. Good nuclear and cytoplasmic contrast was obtained, and the staining time was reduced from 5 to 20 minutes to about 20 seconds.

The cells of the circulating blood consisted of nucleated erythrocytes, small and medium-sized lymphocytes, thrombocytes, and coarse and fine granulocytes (leukocytes containing either neutrophilic, basophilic, or eosinophilic granules). Senile and also immature erythrocytes were commonly noted. The immature forms were identified by their circular outline and the presence of reticulum in their cytoplasm, which was evident in the fixed stained film. Films prepared from fish bloods were characterized by the presence of much more debris and disintegrating cells than could be found in films prepared from mammalian bloods.

The erythrocytes on the stained film were examined for variation in size, shape, hemoglobin content, and abnormal inclusions. Relative numbers of the different types of leukocytes were enumerated, and this formed the basis of the differential count. When counting leukocytes, it was important to have a truly representative sample of the blood. At least 200 cells were counted, and these were from the areas of median cell concentration. Excessively light or congested areas were avoided. Also, the edges of the smear were not included because of the tendency for the cells to clump. The total leukocyte count was computed on a 100-percent basis. For detailed description of types of cells, see Miale (1958).

Discussion

Hematology at the present time is being employed at many fishery stations for values in hemoglobins, hematocrits, and erythrocyte counts. At this point it seems important that standard methods be established and adopted. This will help to eliminate some of the percentage of error encountered between laboratories performing the same examinations. For example, let us consider the practice of severing the caudal peduncle of a small fish to obtain a blood sample. This seems to be the most accepted method of obtaining blood samples from small fish; yet if the posterior portion is not carefully dried before the caudal peduncle is severed, moisture adhering to the fish's body will dilute the blood sample and thus increase the error in all the procedures. A similar error would be encountered by adding too much liquid anticoagulant to a blood sample and thus presenting a dilution factor (a very common practice).

It is the habit of some technicians, when making erythrocyte counts, to count only two squares. This total is divided by 2 for the average; this average is multiplied by 5 for a total of the five squares;

[5] Available from the Hemal Stain Company of Danbury, Connecticut.

[6] See footnote 2, page 164.

[7] See footnote 1, page 164.

the total of the five squares is in turn multiplied by 10^6 for the total erythrocyte count in cells per cubic millimeter. This makes a good estimate but not an accurate count. The same applies to the leukocyte count made by counting only two instead of the four squares. It must be understood that the technician tries to get an even distribution of cells over the counting chamber, but there is always a variable in the concentration of cells in each of the squares counted. It is therefore imperative that each technique be followed very carefully.

The Sahli-Hellige hemoglobin method using 0.1 N hydrochloric acid gave fair results on fish blood. Other methods, such as the carbonate and cyanmethemoglobin, were not too satisfactory. The fish blood formed a gelatinous mass in either of these two solutions, so that the use of them was questionable.

The microhematocrit was somewhat of a revelation in human medicine. It transformed a long procedure which required from 1 to 5 milliliters of blood and 15 to 30 minutes in the centrifuge to a procedure which requires 2 drops of blood and 2 to 3 minutes in the centrifuge. This method was perfect for fish hematology where only small amounts of blood are available.

Stains for differential smears are quite flexible, and the majority give good results. The use of various stains depends a great deal on the technician doing the work. At this laboratory we have selected the Hemal blood-film stain. This selection was due primarily to these factors: (1) Staining time was reduced from minutes to seconds; (2) good nuclear and cytoplasmic staining qualities were obtained.

Summary

Before normal values can be established in fish hematology, it is imperative that suitable methods and techniques be established for the identification and enumeration of the cellular constituents of fish blood.

Techniques adaptable to fish hematology were reviewed and evaluated. A diluting fluid developed by Hendricks was found most effective for routine erythrocyte counts, holding the cells in suspension and producing little or no variation in cellular structure. The leukocyte-erythrocyte combination was most satisfactorily evaluated with a diluting solution developed for avian bloods. A new stain, the Hemal, proved very satisfactory for the differential smears, reducing staining time from 15 to 20 minutes to 20 seconds. Numerous anticoagulants were available for laboratory use, but heparin proved to to be the most effective and caused the least variation in the cellular structures. The standard microhematocrit method was employed on fish blood with very satisfactory results. Hemoglobin from fish blood was determined by the Sahli-Hellige method using 0.1 N hydrochloric acid as a diluent. Blood samples were obtained by severing the caudal peduncle from small fish. Fish over 6 inches in length were successfully anesthetized, and blood was taken by cardiac puncture.

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The Division of Biological and Medical Sciences of the National Science Foundation announces that the deadlines for the receipt of basic research proposals in the Life Sciences are on or about May 15, September 15, and January 15. Disposition of the proposals will be made approximately 4 months after each closing date.

All inquiries about these proposals should be made to the National Science Foundation, Washington 25, D. C.

"A List of Common and Scientific Names of Fishes From the United States and Canada" (2d edition, 1960) has appeared as Special Publication No. 2 of the American Fisheries Society and may be obtained for $1 (paper cover) or $2 (cloth cover). Orders, accompanied by remittance payable to the American Fisheries Society, should be addressed to E. A. Seaman, Secretary-Treasurer, American Fisheries Society, Box 483, McLean, Virginia.

GROWTH OF STUNTED CHANNEL CATFISH

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SOME PRELIMINARY OBSERVATIONS ON THE GROWTH OF CHANNEL CATFISH, Ictalurus punctatus (Rafinesque), when transplanted from crowded to uncrowded ponds in Kansas have been reported by Tiemeier (1957). Davis (1959) presented data on the growth of stunted channel catfish moved from poor to better environments in Kansas; and Greene (1955) found increased growth in stunted brook trout transplanted from mountain streams to lakes in Wyoming.

This paper summarizes the additional growth data obtained from Kansas Flint Hills farm ponds from 1954 through 1959. The nine ponds concerned are from a series of 30 representative unmanaged farm ponds near Manhattan on which there have been studies since 1953. Descriptions of the terrain, climate, limnology, stocking histories, and growth studies have been presented by Tiemeier and Moorman (1957) and Tiemeier and Elder (1957).

One pond, on the George Dugan farm at Leonardville, covers about 2 acres and has a maximum depth of 6 feet. The pond was drained in 1953 and was restocked in the spring of 1954 with thirteen 1- to 4-pound channel catfish, sixty 5- to 6-inch white crappie (Pomoxis annularis Rafinesque), and ten 4-inch green sunfish (Lepomis cyanellus Rafinesque). At the same time this pond was stocked with fish, several tubs, buckets, and even some old automobile trunks were put into a shallow (about 2 feet) water site as possible spawning places for the catfish.

Hatches of catfish were obtained in the summers of 1954 and 1955. The spawning containers were removed in 1955, and--because most were buried in silt--it was believed that only two or three had been used.

The crappies and sunfish also spawned in this pond but never became abundant.

When seine data indicated that the Dugan pond was probably overpopulated, we obtained permission to stock some of the surplus channel catfish in other farm ponds. Since the spring of 1955, six ponds have been stocked once; each of two additional ponds has been stocked twice (tables 1 and 2). Stockings were made for a variety of reasons; i.e., to make initial plantings in new ponds, to restore depleted populations in heavily fished ponds, to restock after drought-kill or rotenone treatment.

Methods

Samples of catfish from which we obtained length, weight, and age data were collected by means of periodic intensive seinings, usually early in June and early in September. Equipment used included minnow seines (0.25-inch mesh), a 50- by 8-foot seine (0.5-inch square mesh), and various lengths of 1-inch square mesh seines in 6-, 8-, and 10-foot depths. Turbidity readings were made biweekly from

Contribution No. 302, Department of Zoology, Kansas Agricultural experiment Station, Manhattan, in cooperation with the Kansas Forestry, Fish and Game Commission.

TABLE 1.--Physical characteristics and stocking histories of Flint Hills farm ponds stocked with stunted channel catfish

Pond	Size (acres)	Turbidity classification	Stocking history				Other fish present
			Date stocked	Number stocked	Age of stocked fish	Hatch	
Dugan----------	2.0	Muddy---------		Source pond			Crappie, green sunfish.
Wells No. 1-----	.3	Intermediate--	Spring 1955	35	I	1954	None.
Wells No. 2-----				15	0	1955	
Burgess No. 6---	.5	Intermediate to slightly muddy.	Spring 1956	59	I	1955	None.
Ebel----------	.8	Intermediate--	Spring 1957	87	II	1955	Green sunfish.
Horne No. 1-----	.5	Clear---------	Spring 1957	37	II	1955	Bass and bluegills.
Woodruff No. 1--	2.0	Clear to intermediate.	Spring 1956	50	I	1955	Bass and bluegills.
Woodruff No. 2--			Fall 1958	53	III & IV	Both	
Avery No. 3-----	.3	Intermediate--	Spring 1957	50	III	1954	None.
Fear No. 1------	1.0	Muddy---------	Fall 1958	56	III & IV	Both	Young-of-year catfish.
Fear No. 2------	1.0	Muddy---------	Fall 1958	56	III & IV	Both	Young-of-year catfish.

TABLE 2.--Summary of length and weight averages from Flint Hills farm ponds stocked with stunted channel catfish
(L = length (inches); W = weight (grams))

Pond		1954 Fall	1955 Spring	1955 Fall	1956 Spring	1956 Fall	1957 Spring	1957 Fall	1958 Spring	1958 Fall	1959 Spring	1959 Fall
Dugan (1954)	L:	2.0	4.0	4.9 (18)[1]	------	5.6 (25)	5.9 (18)					
	W:	----	--------	16.1 (35)	------	17.0 (25)	23.0 (18)					
	L:							6.1 (79)[2]	----------	7.2 (39)	7.7 (343)	11.3 (141)
	W:							26.5 (79)	----------	45.2 (21)	62.8 (514)	206.0 (141)
Dugan (1955)	L:	----	--------	2.5 (6)	3-3.4	3.9 (5)	4.7 (18)					
	W:	----	--------	4.5 (25)	------	4.0 (25)	12.0 (18)					
Wells No. 1	L:	----	3.6 (35)	----------	------	11.8 (6)	---------	----------	---------	---------	----------	----------
	W:	----	--------	----------	------	206.0 (6)	---------	----------	---------	---------	----------	----------
Wells No. 2	L:	----	1.0 (15)	----------	------	8.3 (3)	---------	----------	---------	---------	----------	----------
	W:	----	--------	----------	------	71.0 (3)	---------	----------	---------	---------	----------	----------
Burgess No. 6	L:	----	--------	----------	3-3.4	9.3 (11)	---------	15.5 (20)	16.8 (3)	---------	----------	20.4 (10)
	W:	----	--------	----------	------	95.0 (11)	---------	540.0 (20)	670.0 (3)	---------	----------	1061.0 (10)
Ebel	L:	----	--------	----------	------	----------	4.7	10.9 (12)	12.8 (16)	13.6 (16)	15.2 (19)	16.5 (27)
	W:	----	--------	----------	------	----------	12.0	190.0 (12)	258.0 (16)	312.0 (16)	512.0 (19)	630.0 (27)
Horne No. 1	L:	----	--------	----------	------	----------	4.7	----------	----------	----------	----------	18.9 (17)
	W:	----	--------	----------	------	----------	12.0	----------	----------	----------	----------	889.0 (17)
Woodruff No. 1	L:	----	--------	----------	3.4	----------	---------	----------	----------	19.5 (1)	----------	19.5 (2)
	W:	----	--------	----------	------	----------	---------	----------	----------	1107.0 (1)	----------	965.0 (2)
Woodruff No. 2	L:	----	--------	----------	------	----------	---------	----------	----------	7.2 (39)	----------	13.0 (2)
	W:	----	--------	----------	------	----------	---------	----------	----------	45.2 (21)	----------	237.0 (2)
Avery No. 3	L:	----	--------	----------	------	----------	5.9 (18)	11.6 (15)	12.0 (9)	----------	15.4 (3)	----------
	W:	----	--------	----------	------	----------	23.0 (18)	166.0 (15)	230.0 (9)	----------	473.0 (3)	----------
Fear No. 1	L:	----	--------	----------	------	----------	---------	----------	----------	7.2 (39)	11.0 (2)	16.2 (22)
	W:	----	--------	----------	------	----------	---------	----------	----------	45.2 (21)	233.0 (2)	743.0 (22)
Fear No. 2	L:	----	--------	----------	------	----------	---------	----------	----------	7.2 (39)	10.5 (2)	14.1 (4)
	W:	----	--------	----------	------	----------	---------	----------	----------	45.2 (21)	201.0 (2)	617.0 (4)

[1] Figure in parentheses denotes size of sample.

[2] Year-classes no longer separable on length-weight basis.

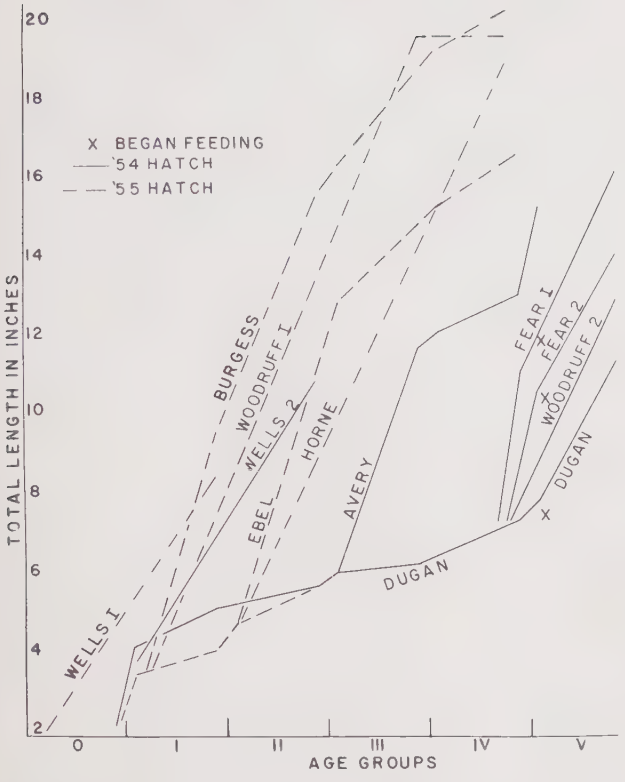

FIGURE 1.--Comparison of growth (in total length) of channel catfish in Dugan and other ponds.

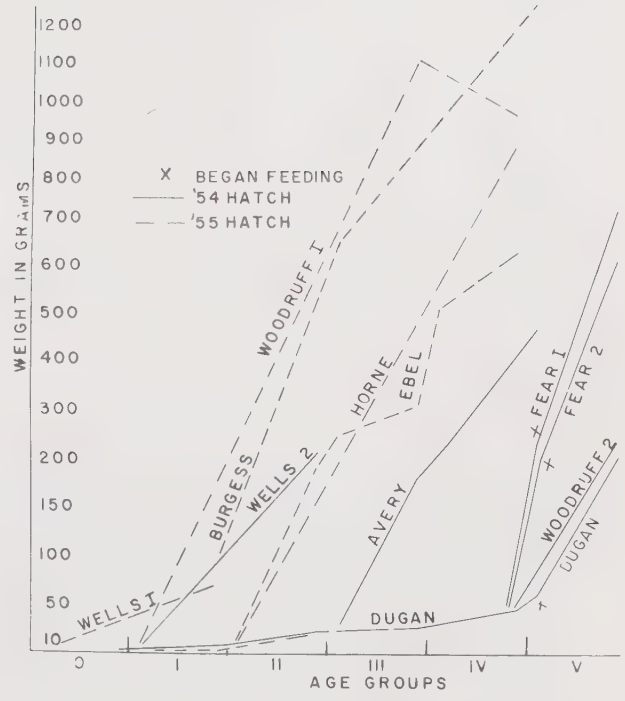

FIGURE 2.--Comparison of growth (in weight) of channel catfish in Dugan and other ponds.

early in June through October with a Hellige platinum-wire turbidimeter. The turbidity classifications of the pond follow the criteria used by Tiemeier and Moorman (1957), in which ponds averaging 0 to 40 p.p.m. turbidity were considered clear; 41 to 100 p.p.m., intermediate; and over 100 p.p.m., muddy.

Results

Averages of growth in length and weight of stocked fish and parent populations are given in table 2 and figures 1 and 2. In general, at the end of one growing season in the new pond environment, sizes of the stocked channel catfish compared favorably with the sizes of fish of the same age from other areas in the Midwest (Carlander 1953). After the spring of 1957 it was no longer possible to differentiate between the 1954 and 1955 hatches in the Dugan ponds on the basis of size; so the three stockings made after 1957 were assigned to the 1954 year-class.

It appeared that available food in the Dugan pond was adequate for maintenance of numerous small catfish but insufficient for good growth. Though small and slender, these fish did not appear starved. During one season (April to October 1959) of supplemental feeding with experimental prepared fish pellets, the fish grew from an average of 7.74 inches and 63 grams to an average of 11.4 inches and 206 grams (table 2). The growth response to supplemental feeding clearly demonstrated that shortage of food was the factor inhibiting growth. Similar results were obtained through supplemental feeding in the two Fear ponds (figures 1 and 2). The greater growth response of stocked channel catfish to supplemental feeding in the Fear ponds--greater as compared with that of the parent population--probably can be ascribed to the presence of smaller numbers of fish, and hence less competition, in the Fear ponds.

The size to which the stocked fish grew appeared to depend on the length of time they had been stocked in the new environment. The slope of the growth lines is as steep for age group IV catfish stocked in the Woodruff and Fear ponds as it is for fish stocked earlier in other ponds (figures 1 and 2).

The presence of large and established populations of largemouth bass, Micropterus salmoides (Lacepede), and bluegills, Lepomis macrochirus Rafinesque, did not prevent the transplanted channel catfish from growing well. Nor was an inhibitory effect found in the high turbidities encountered in three of the ponds (table 1). No relation between turbidity and growth of catfish was found in any of the ponds. Pond area apparently had no effect on growth: fish made satisfactory growth in the smaller as well as in the larger ponds. We have recommended that in this region unmanaged ponds smaller than 0.5 acre should not be stocked because of the susceptibility of small ponds to winterkill. No fish were recovered from the Wells pond after the second year of stocking, evidently because of winterkill during a period of low water after drought.

It was concluded, therefore, that the retardation of growth of channel catfish in an overpopulated pond did not affect them permanently. Results from all stockings demonstrated that they quickly recovered growth when stocked in ponds not already stocked with large numbers of catfish.

So far, insufficient data have prevented determination of whether stunted channel catfish gained more rapidly after being released from overcrowding than channel catfish that had never been stunted. The question is, Will age group IV catfish that were transplanted as age group II stunted catfish reach the same size as age group IV catfish stocked originally in a new pond environment in proper numbers? Studies are continuing for an insight into this question.

Summary

1. The growth of stunted channel catfish transferred from an overcrowded pond to ponds with and without channel catfish was investigated between 1955 and 1959.

2. Stocked fish reached catchable size after 1 year in new environments, irrespective of age when stocked; whereas fish in the parent population were still below usable size in year-classes IV and V.

3. Rapid growth of the parent population when given supplemental feed indicated that shortage of food was the factor limiting growth.

4. No apparent relation was found between growth rate of stocked fish and turbidity, size of pond, or presence of populations of other species.

Acknowledgments

Cooperation of the farmers and landowners who permitted use of their pond areas is gratefully acknowledged.

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SODIUM CYANIDE IN FISH MANAGEMENT AND CULTURE

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SODIUM CYANIDE is a deadly poison both as a salt and when converted into hydrogen cyanide by the action of acids. Both the salt and the gas should be treated with great caution.

Though the concentration of sodium cyanide required to anesthetize fishes is not high enough to constitute a serious hazard to the health of higher animals, there are laws governing the addition of pollutants to public waters. A Federal law prohibits the introduction of foreign substances into water that crosses a State line, and the various States have anti-pollution laws. In planning the use of cyanide, these regulations should be taken into account.

Bridges (1958) reported sodium cyanide to be an effective fish poison. The present work constitutes an accumulation of observations on 23 poisoning operations designed to give information on more specific uses of the chemical.

Application of Cyanide

Because of the hazard, the handling of cyanide should be held to a minimum; yet success in its use requires that the cyanide be well distributed and mixed.

The sodium cyanide used is in the form of "Cyaneggs" (figure 1) weighing approximately 1 ounce. Use of these eggs or a similar form is desirable because there is less danger of accidents (from wind, for example) than there would be with a granular or powder form. Further, the uniform weight of the eggs makes it unnecessary to weigh the chemical. Rubber gloves are used in handling the eggs, and care is taken to prevent the eggs from becoming damp while being handled.

FIGURE 1.--Sodium cyanide in the form of Cyaneggs.

After considerable experience, two different means of applying the cyanide have been adopted. The method of application varies with the size and accessibility of the body of water being poisoned. For applications in small hatchery ponds,

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This study was financed in part by the Illinois Department of Conservation.

FIGURE 2.--Wire baskets and rope used to apply sodium cyanide in hatchery ponds.

the eggs are placed in two 0.25-inch-mesh wire baskets attached to a haul line (figure 2) that extends completely across the pond. Then, with a person at each end of the line, the baskets are dragged back and forth and from side to side through the pond. No additional mixing is necessary. For larger ponds and closed-off coves of lakes, the eggs are placed in a weighted open-mesh bag and towed behind a boat. After the eggs have dissolved--which requires about 20 minutes--an outboard motor is used for further mixing.

Sodium Cyanide for Fish Removal

Sodium cyanide is an excellent means of live removal of larger centrarchids from ponds as much as 1 or 2 acres in size. A concentration of 1.0 p.p.m. is required, although fish can be salvaged at concentrations as high as 4.0 p.p.m. The removal of young-of-the-year and brood bass (Micropterus salmoides) from one 0.4-acre brood pond in January (water temperature, 39° F.) illustrates the possibilities of cyanide for live-removal work. Sodium cyanide at the rate of 2.5 p.p.m. was applied at 12:10 p.m. At 12:22, fish began to react. Collections were made continuously from 12:55 to 5:00 p.m. The cumulative counts of captures at various times were as follows: 12:55 p.m., 957; 1:22 p.m., 1,215; 2:30 p.m., 1,268; 3:15 p.m., 1,276; and 5:00 p.m., 1,284. The pond was drained the day after poisoning, and only 11 young-of-the-year and 2 brood bass were found dead.

Although a portion of a carp (Cyprinus carpio) or bullhead (Ictalurus spp.) population will surface in such condition as to be captured and revived, live capture of these species is quite inefficient as compared to the live capture of centrarchids. Golden shiners (Notemigonus crysoleucas) are captured fairly effectively by using a concentration of 4.0 p.p.m., but the time available for dipping is limited when such a high concentration is used.

This variation in its effectiveness for different species appears to result from a difference in susceptibility of the species to the poison. In aquaria, 0.25 p.p.m. at 76° F. was not fatal to the golden shiner or black bullhead (Ictalurus melas) in 72 hours; but under the same conditions 8 out of 10 green sunfish (Lepomis cyanellus) died. In a pond poisoning operation at 2.0 p.p.m. at 65° F., bass and bluegills (L. macrochirus) began to react within 30 minutes after the cyanide was applied; but large golden shiners did not begin to surface until 2 days after the poison was applied.

When capture and revival of fish are planned, a number of persons are needed to dip out the surfacing fish. The exact number of persons varies with the number of fish to be salvaged and the size of the pond. On a typical operation we have five to seven persons dipping. In small ponds most of the fish can be dipped from the bank; however, a boat is of considerable value in larger ponds. The fish that are dipped must be placed in fresh water; hence each person netting fish must have a conveniently located tub, and live tanks must be available for handling the anticipated number of fish.

The surfacing and anesthetization of centrarchids appear equally good in summer or winter. This is illustrated by comparing the fish removal from two farm ponds, Schoen's and Pearl's. Schoen's pond was poisoned in July (water temperature, 80° F.), and Pearl's pond was poisoned in February (water temperature, 46° F.). Cyanide was added to Schoen's pond at 7:30 a.m., and pickup was stopped

at 9:00 a. m. Thirty-eight bass, weighing a total of 27. 5 pounds, were captured and revived. On the day after the poisoning, four bass, weighing a total of 1 pound, were picked up; in subsequent days no more bass were collected. The actual loss thus amounted to 10 percent of the bass present.

Cyanide was applied to Pearl's pond at 11:30 a. m. Maximum surfacing occurred at 1:30 p. m. Pickup stopped at 2:15 p. m. Bass weighing a total of 8. 5 pounds were taken the day after the poisoning. The loss was thus negligible.

Cyanide is lost more rapidly from warm water than from cold. In aquarium studies made at 66° to 80° F., 10 days were required for the water treated with 1 p. p. m. to become nontoxic to green sunfish. At 45° to 48° F., 64 days were required. In the field, however, less time is required for detoxification. By using caged fish it was determined that Schoen's pond, with a surface temperature of 80° F., detoxified in 4 days; whereas Pearl's pond, with a surface temperature of 46° F., required 10 days. Another pond, Tar Hill Pond, with a surface temperature of 36° F., required 9 days. The higher rate of detoxification in the field as compared to the rate in aquaria is to be expected, as major differences in pH, aeration, and chemical constituents occur.

The rapid rate of detoxification during the summer results in a higher atmospheric concentration of hydrogen cyanide and thus creates a less desirable situation as far as safety of personnel is concerned. This does not mean that a great danger to personnel is involved, even though personnel must remain in the contaminated area for 3 to 4 hours.

Low temperature is desirable when a large number of larger fish are being handled and transported; and, all things considered, we recommend that live-removal work be done in the winter if possible.

Use of Cyanide in Hatcheries

Sodium cyanide at 4 p. p. m. will kill all fish, tadpoles, and at least some species of aquatic insects (Notonectidae and and Corixidae). In addition to controlling these insects, cyanide affects snails and Daphnia. In aquaria, snails of the genus Physa were subjected to sodium cyanide in various concentrations that produced partial kills. By extrapolation it was established that 100 percent mortality would occur at 2. 6 p. p. m. Mussels of the genus Anodonta were not killed in a hatchery pond treated with 3. 0 p. p. m. In aquarium studies Bridges (unpublished) obtained 100 percent mortality of Daphnia with concentrations as low as 3. 0 p. p. m. Seemingly, the 4. 0 p. p. m. recommended for clearing hatchery ponds would eliminate most invertebrate forms; however, aquarium results and field results are usually not the same.

Sampling Large Lakes With Cyanide

To sample a large lake, a divider is used to close off a 1- or 2-acre cove. A satisfactory divider can be made of 4-mil polyethylene. Snap-lid glass fruit jars of pint size serve as floats, and sand-filled jars of the same type serve as weights. The jars are placed at 6-foot intervals. They are attached to the sheet by clamping the plastic between the jar and the lid. The rubber gasket for the jar is not used. In addition to being suspended by the jars, the divider is held in place by tying it to a stake placed at each end. Installation of the divider is greatly facilitated by first stretching a rope across the location where the divider is to be installed. The rope is then used as a means of moving a boat from which the divider is laid out.

After the divider is in place, poisoning is conducted as described under methods of application. For a complete sample of fish, it is necessary to pick up fish for as many as 7 days after poisoning in the winter but only 1 or 2 days in warm weather.

Sampling Streams With Cyanide

In sampling a small pool-and-riffle stream, Stegman (1959) found sodium cyanide much more efficient than a combination of seining and shocking. Thirteen

trips in which seining and shocking were combined resulted in the collection of 1 golden redhorse (Moxostoma erythrurum), 9 logperch (Percina caprodes), 1 blackside darter (P. maculata), 3 silverjaw minnows (Ericymba buccata), no channel catfish (Ictalurus punctatus), and no spotted bass (Micropterus punctulatus); whereas 4 collections with cyanide produced 37, 13, 17, 26, 5, and 2 of each species, respectively.

When used for stream sampling, the cyanide is applied with a hand dip net. A seine is placed downstream to catch the incapacitated fish.

Conclusions

After 2 years of experience with cyanide and association with Mr. Bridges in his work, the authors are convinced that sodium cyanide has an unusual potential in fish culture, management of small ponds, and sampling of large lakes. It is difficult to imagine any substance's being more suited to the preparation of rearing and brood ponds. Sodium cyanide is easily applied, effective, inexpensive, and under normal conditions would not be expected to have any residual effect beyond the few days required for loss of acute toxicity. It would be regrettable if cyanide's reputation as a toxicant to warm-blooded forms should prevent its being appropriately used in fishery work.

Acknowledgments

The authors wish to thank Mr. Edward Lyles and Mrs. Sue D. Lewis for contributing to the collection data for this paper.

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ALGAL PARASITE IN FISH

On April 4, 1960, the Eastern Fish Disease Laboratory received 30 diseased swordtail (Xiphophorus helleri) and kissing gourami (Helostoma temmineki) from a large fish farm in Florida. There had been considerable mortality at this farm.

Some of these fish were greatly emaciated, and most of them had clubbed gills. Most of the fish died in transit or soon after arriving. Microscopic examination revealed many algal cells in the epithelium of the skin and gills.

The alga found resembles, or may be, Mucophilus cyprini Plehn of Europe, described by Plehn in 1920 (Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, 85 (4): 275-281). It is 15 to 20 microns in diameter and has 8 to 12 green chloroplasts about 5 microns in diameter. This alga can be recognized by the green of the chloroplasts, but may be confused with pigment cells of the fish. On one fish a small cluster of these algae was found under a scale. The cluster was about half a millimeter in diameter, but was not easily recognized without magnification. The parasites were found also in the viscera. The only other records of algal parasites in fresh-water fish in North America are Oodinium limneticum Jacobs, a dinoflagellate (Jacobs, D. L., 1946, Transactions, the American Microscopical Society, 65: 1-17); and Cladophora, a filamentous green alga (Vinyard, W. C., 1955, Proceedings, the Oklahoma Academy of Science, 34: 63-65).

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EVALUATION OF COMMERCIAL FISHING BY USE OF A QUESTIONNAIRE

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COMMERCIAL FISHING in the State of North Dakota is restricted by law to the Missouri and Yellowstone Rivers. The primary purpose of commercial fishing is to obtain food for home use, although some fish are sent to local markets for retail.

Commercial fishing is legal throughout the year, but the greatest effort is made from May to October. The use of hoop nets, set lines, and seines is permitted. The set lines, most widely used because of their low cost and ease in handling, are usually fished in all currents at depths of 5 to 15 feet; hoop nets, which require more effort and skill, are fished in slow currents at depths of 3 to 10 feet; seines are effective in shallow bays. The baits utilized include cheese, cut bait, and minnows. Game fish taken with commercial gear must be returned, as provided by the fish code. Commercial fishermen are requested to keep a record of the numbers and weights of all the fish taken, including the game fish which are subsequently released.

In 1953, a survey was made of the fishery in the Missouri and Yellowstone Rivers. The survey was initiated at that time in order to secure information before river habitat was lost as a result of the construction of Garrison Dam. The North Dakota Game and Fish Department compiled information regarding commercial utilization, including a comparison of the catches made with various types of gear and a tabulation of the poundages of fish taken.

Technique Used

Information about the catch was obtained by means of a mail questionnaire. The return of 45.3 percent of the forms during the first year (1953) prompted the use of the questionnaire from 1954 to 1957. This writer did not find any literature on the use of questionnaires as a means of determining commercial fishing trends. However, mail questionnaires were successfully used for the sampling of sport-fish catches (Calhoun 1950, 1951, 1953; Clark 1953).

The names and addresses of all commercial fishermen are kept in the office of the North Dakota Game and Fish Department in Bismarck. At the end of each calendar year, a questionnaire (figure 1) was sent to all persons who purchased a commercial fishing permit. All of the licensees were asked to fill in and return the questionnaire whether they fished or not. Most of the questionnaires were promptly filled in and returned. An average of 5 percent of those who returned a questionnaire did not fish. Commercial fishermen reported this information voluntarily.

Six weeks after the questionnaire had been mailed, a follow-up letter was sent to those who had not responded. This letter brought in an additional 5 to 8 percent returns. Detailed information was transferred from the questionnaires to yearly summary sheets, and averages were calculated for each commercial fisherman.

Commercial Fishery Questionnaire
Year_____

County:

Type of gear and number
Hoop net_____
Set Line_____
Seine _____

Did you use a boat?_____
Kind: Wood _____
Metal _____
Motor _____

Bait Utilized:_____

Areas Fished Most
Currents_____
Depths _____
Other _____

Month you fished most? _____
Month of best fishing?_____
Number of days spent fishing?_____

Investment of Equipment: $_____
Cost of Operations: $_____

Did you sell catch?_____, or for own use_____

Did not fish:_____

Catch

Species	Total number	Total pounds	Value of catch
Channel Catfish			
Carp			
Bullheads & Madtoms			
Burbot			
Suckers			
Goldeye			
Buffalofishes			
Sturgeon			
Flathead Chub			
Shortnose Gar			
Gizzard Shad			
Paddlefish			
Freshwater Drum			
Sauger			
Walleye			
Northern Pike			
Rainbow Trout			
Yellow Perch			
Sunfishes			
Others			

Remarks_____

Name_____

Game & Fish Department
Division of Fisheries Management
Bismarck, North Dakota

FIGURE 1.--Questionnaire used for survey of commercial fishing trends.

TOTAL NUMBER AND POUNDAGE OF FISH, 1953-57

/Percentages in parentheses/

Year	Food fish[1]		Rough fish[2]		Game fish[3]	
	Number	Pounds	Number	Pounds	Number	Pounds
1953	46,061 (55.0)	54,967	36,417 (43.8)	43,458	665 (0.8)	794
1954	24,344 (51.0)	43,690	20,335 (42.6)	36,494	3,055 (6.4)	5,483
1955	27,361 (51.3)	32,957	23,201 (43.5)	27,946	2,773 (5.2)	3,341
1956	24,962 (53.0)	31,867	17,285 (36.7)	22,067	4,851 (10.3)	6,193
1957	22,482 (44.6)	42,376	23,591 (46.8)	44,467	4,335 (8.6)	8,172
Totals--	145,210	205,857	120,829	174,432	15,679	23,983

1/Channel catfish (Ictalurus punctatus), black crappie (Pomoxis nigromaculatus), white crappie (P. annularis), bluegill (Lepomis macrochirus), pumpkinseed (L. gibbosus), yellow perch (Perca flavescens).

2/Shovelnose sturgeon (Scaphirhynchus platorynchus), palled sturgeon (S. album), paddlefish (Polyodon spathula), shortnose gar (Lepisosteus platostomus), gizzard shad (Dorosoma cepedianum), goldeye (Hiodon alosoides), largemouth buffalo (Ictiobus cyprinella), carp sucker (Carpiodes carpio), common sucker (Catostomus commersonni), carp (Cyprinus carpio), flathead chub (Hybopsis gracilis), bullheads and madtoms (Ictaluridae), burbot (Lota lota), freshwater drum (Aplodinotus grunniens).

3/Rainbow trout (Salmo gairdneri), northern pike (Esox lucius), walleye (Stizostedion vitreum), sauger (S. canadense).

Results

The total numbers of commercial fishing licenses issued in the years from 1953 to 1957, inclusive, were: 426, 488, 404, 377, and 1,005. The returns from the questionnaire mailed to these licensees totaled, respectively: 193 (45.3 percent), 288 (59.0 percent), 205 (50.7 percent), 199 (52.7 percent), and 532 (52.9 percent).

Responses to the questionnaire indicated that this group of fishermen made the following use of the three types of fishing gear: set lines, 72 to 82 percent; hoop nets, 17 to 26 percent; and seines, 1 to 3 percent.

Using the hoop net, the fishermen who filled in and returned the questionnaire harvested a total of 245,508 pounds of fish. With set lines, these fishermen caught a total of 149,979 pounds of fish. Their harvest with seines totaled only 8,785 pounds.

Figure 2 shows that the size of the catches made with each of the various types of gear fluctuated during the 5-year period.

The fish caught during this study were classified as food fish, rough fish, and game fish (see table). Food fish (principally channel catfish) made up the largest total catch, which averaged 29,045 fish (weight, 41,171 pounds) a year. Rough fish (mainly goldeye, carp, largemouth buffalo, carp sucker, burbot, and common sucker) made up the next most important group, which averaged 24,166 fish

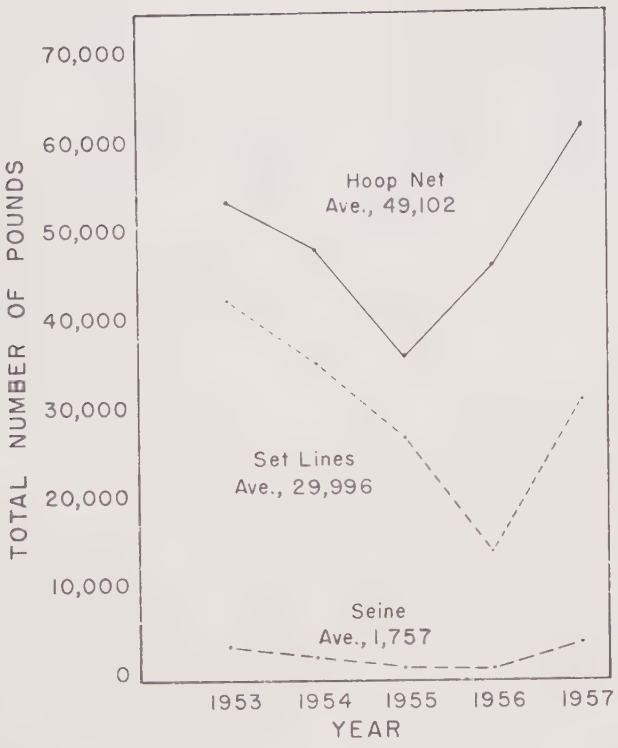

FIGURE 2.--Comparison of catches with various types of fishing gear.

(weight, 34,886 pounds) a year. Game fish (sauger, walleye, northern pike, and rainbow trout) averaged 3,136 fish (weight, 4,797 pounds) a year.

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CANVAS HOLDING TANK

Large numbers of live fish may be held for short periods in a circular tank made of heavy, water-resistant duck canvas with double-sewed seams. The tank is 9 feet in diameter, has a 3-foot wall, and holds about 160 cubic feet of water when filled to a depth of 2.5 feet. The wall is strengthened by hardwood staves (2 by 2's) set vertically at 4-foot intervals and buckled to the canvas at top and bottom, and by an encircling heavy web strap passed through metal loops on the staves 12 inches above the ground. Treated with a waterproofing compound, the tank is made for us by the Danville Tent and Awning Company, Danville, Illinois, for $61.20.

To use, the tank is spread on fairly even ground, the staves are strapped in place, and water is poured within. Rising

water lifts the wall and pushes it outward; thus the tank is self-supporting when full. To drain, the buckle at the top of one stave is loosened and the wall is depressed.

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PREVENTING A WINTERKILL BY USE OF A COMPRESSED-AIR SYSTEM

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FOR SEVERAL YEARS THE STATE OF WYOMING had been trying to get a supply of eggs from the cutthroat trout (Salmo clarki lewisi) native to the Snake River drainage. The attempts to trap existing spawning populations and to rear a brood stock in the hatcheries had met with indifferent success. With increases in fishing pressure, in water uses, and in other human-population pressures, it became imperative that a source of these eggs be established if the native cutthroat trout were to be preserved in the Snake River drainage. Also, it was known that a supply of these cutthroat trout would be needed for the proposed Federal fish-cultural station to be built in Jackson, Wyoming.

It was decided that the establishment of a brood lake would be the best solution to the need for immediate production. Soda Lake, in northwestern Wyoming, was chosen as the brood lake. Although there was no recorded biological or chemical history of this lake, it was known to have supported a trout population for a few years. As there were no facilities for natural reproduction in the lake, the population had died out.

Soda Lake is a landlocked lake at an elevation of 7,600 feet. Its only source of water is spring runoff from a very small drainage and a few small spring seeps. It is a natural lake of 60 surface acres and has a maximum depth of 40 feet. The lake is oval in shape and has extensive shoal areas in both ends. These shoal areas support a luxuriant growth of aquatic vegetation. The lake has a total alkalinity of 303 p.p.m. and is very productive.

In 1956 Soda Lake was stocked with 22,000 Snake River cutthroat trout fingerlings for use as brood stock. During the winter of 1957-58, water analysis indicated that winterkill was very possible during a severe winter.

Because of the extreme shortage of Snake River cutthroat trout eggs, it was felt that an attempt to prevent winterkill was essential.

The operational plan was to remove part of the ice cover from Soda Lake, through the use of compressed air, and thereby allow an exchange of oxygen, carbon dioxide, and hydrogen sulfide. Compressed air was bubbled from the lake bottom through perforated plastic pipe, causing upward convection currents to bring the warm bottom water into contact with the ice cover. Two 1,100-foot sections of 3/4-inch plastic pipe were placed in a teardrop shape in the lake (figure 1). The pipe had previously been drilled with 1/32-inch holes every 20 feet. Anchor rocks were attached to the pipe at 20-foot intervals, with 4 feet of rope between the pipe and the rock so that the pipe would float free of any bottom muck.

The compressed air was supplied by a Jaeger 75-c.f.m. compressor powered by

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Constructed in 1957, the National Fish Hatchery at Jackson, Wyoming, has been in operation since 1958.--The EDITOR.

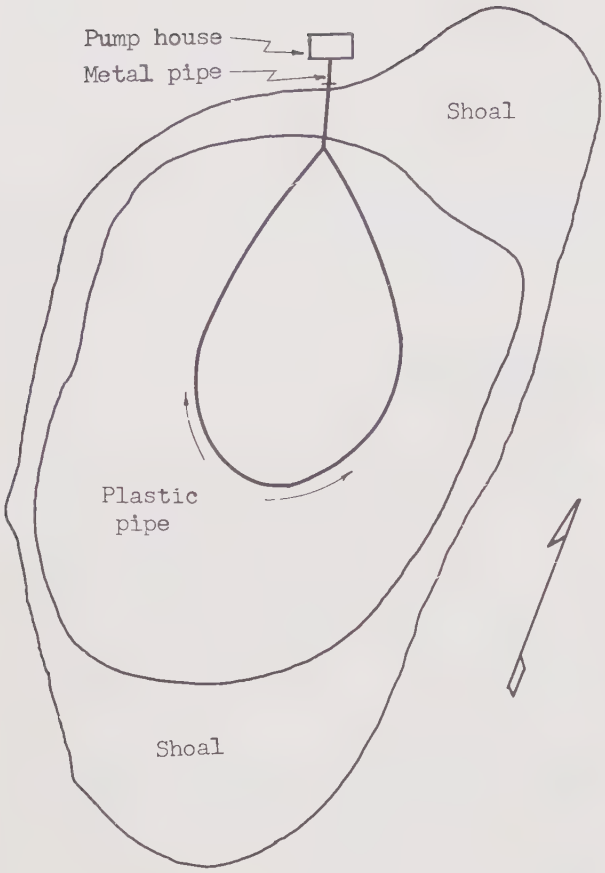

FIGURE 1.--Diagram of Soda Lake and pipe layout.

a 25-horsepower gas engine. Owing to the high temperature of the compressed air, metal pipe was used for the first 15 feet from the compressor to prevent melting of the plastic pipe. A valve was placed in the pipe between the compressor and the lake. By closing this valve, enough air could be trapped in the pipe to prevent water from entering and freezing during short periods (overnight to 3 days) when the pump was not in operation. When the pump was not to be used for prolonged periods, the pipe was disconnected where it entered the lake.

Daily records were kept on air and water temperature, ice thickness in and out of the pump area, length of operating time to melt the ice, and time required for freezeup. Once a month, water analysis was made for the following: dissolved oxygen, pH, carbonate and bicarbonate alkalinity, sulfides, chlorides, calcium, and magnesium. Gill nets were set throughout the winter to check on survival and egg development.

The ice cover on Soda Lake was complete on November 13, 1958. Pumping was begun on November 17, 1958, and continued to April 29, 1959. Initial operation took 22 hours to open a channel 50 feet wide over the entire pipe. (See figure 2.) At this time the ice was 6 inches thick.

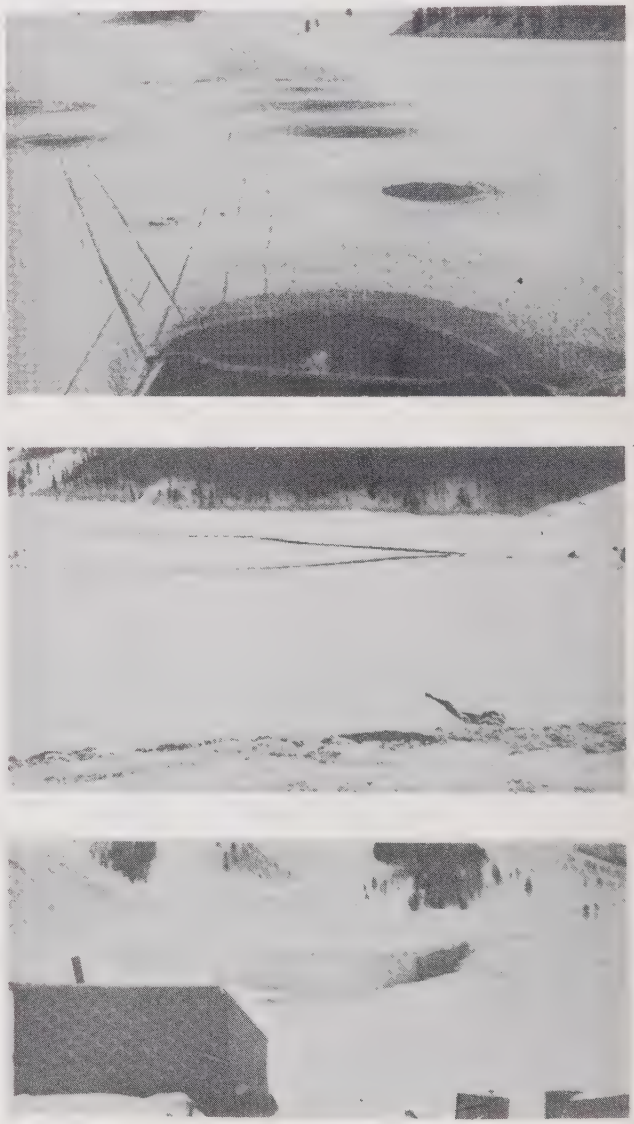

FIGURE 2.--(Top) Soda Lake after 1/2 hour of pumping. (Center) Soda Lake after 1 hour of pumping. (Bottom) Soda Lake after 3 hours of pumping.

No matter what the air temperature, about 1-1/2 inches of new ice would form over the pump area every night there was no wind action. Wind action would keep the pump area ice-free. However, as Soda Lake was in a protected basin, there were only 18 days during the entire winter when there was enough wind action to prevent freezing. The air temperature ranged from 36° to -30° F. during the pumping operation. Outside the pump area, maximum thickness of ice was 19 inches with 2 feet of snow cover.

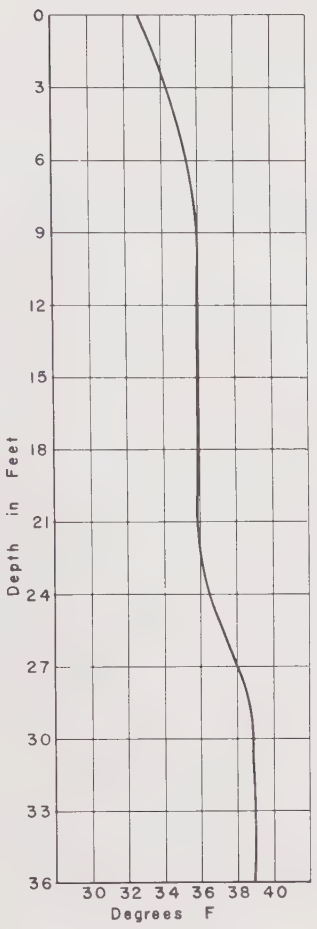

FIGURE 3.--Chart of a typical water temperature curve in Soda Lake during ice cover.

With the formation of ice, the curve for the water temperature was established; it remained nearly constant throughout the winter (figure 3). After the pump was started, temperatures were erratic because of the convection currents extending over the entire deep-water area of the lake. There was no noticeable loss of heat during the winter.

Dissolved-oxygen levels in Soda Lake were higher than they had been in previous winter checks. In February 1958, the dissolved oxygen was 4.9 p.p.m. at the surface and only a trace from 4 feet down. With operation of the pump, the dissolved oxygen was more evenly distributed. The dissolved-oxygen levels in the pump area were as follows: surface, 4.9 p.p.m.; 10 feet, 4.0 p.p.m.; 20 feet, 3.8 p.p.m.; and 30 feet, 3.2 p.p.m. Checks of dissolved oxygen were also made under the ice-covered part of the lake at intervals of 50 feet and 100 yards from the pump area. At the 50-foot station, dissolved-oxygen levels were: surface, 4.3 p.p.m.; 10 feet, 3.5 p.p.m.; 20 feet, 3.2 p.p.m.; and 30 feet, 2.7 p.p.m. At the 100-yard station, the dissolved-oxygen levels were: surface, 3.8 p.p.m.; 10 feet, 3.3 p.p.m.; 20 feet, 2.7 p.p.m. These levels held steady from December through March.

The pumping operation lasted 162 days, during which the compressor was run 632 hours or an average of 3.9 hours per day. Cost of the installation and operation, exclusive of the operator's wages, was $950.

Observations with a glass-faced viewing box did not indicate any concentration of fish in the pump area. However, the rate of catch with gill nets would lead one to believe that there was some concentration of fish in the pump area. It was not uncommon to start picking a gill net as soon as it was set and catch 10 to 15 trout in that short time. Although rather sluggish, the fish seemed to be in excellent physical condition throughout the winter.

Egg development in a small portion of the population seemed erratic. As early as December 8, 1958, egg development in some specimens was as far advanced as in the majority of the fish in March 1959.

Spawning operations were conducted in the last 2 weeks of May 1959. All the fish captured during this work were ripe or became ripe during the 2-week period. As 3-year-olds or first-year spawners, the females averaged 16.1 inches in total length and 2 pounds in weight. They produced an average of 3,000 eggs each. The total take was slightly over 2 million eggs.

The State of Wyoming has now developed other sources of these eggs, so the pumping will not be continued. We feel that if those sources had not been developed, it would have been economically feasible to continue pumping in Soda Lake. As things worked out, the Soda Lake production filled a real gap in the hatchery schedule and gave more time for developing other sources for the spawning of this trout.

AN UNDERWATER CAMERA CASE

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UNDERWATER PHOTOGRAPHY has become an almost indispensable tool in the field of fishery science. Unfortunately, camera housings for use under water, currently available commercially or described in the literature (for examples, Cross 1953 and Thompson 1959), were developed for special use with particular cameras and do not possess the versatility required for use on many field projects.

At the remote Brooks Lake Red Salmon Research Laboratory on the Alaska Peninsula, there was need for an underwater camera case that would fulfill the following requirements: (1) Constructible from common materials generally available at such a field station; (2) capable of housing simultaneously two cameras and possibly an electronic flash unit; (3) provided with a means of manipulating under water controls on both motion-picture and still cameras; (4) portable above water, yet of neutral buoyancy under water; and (5) equipped with a pressure system to prevent leakage and to allow safe use at various water depths and pressures.

The underwater camera case described here was constructed at the Brooks Lake Laboratory. The case fulfilled the special requirements, and excellent underwater photographs were obtained.

Design and Construction

The case was built of 3/4-inch exterior plywood with plexiglass ports. It is large enough to house a 35-millimeter Exakta camera and either a 16-millimeter Bell and Howell 70-DR movie camera, or a 4x5 Graphic press camera. A portable electronic flash unit can be housed inside in place of one of the cameras. The case is 15 inches wide, 17 inches long, and 11 inches high. An exploded view of the case is shown in figure 1.

Brass flathead screws were used to hold the box together; and the joints were sealed with Flex-O-Fix, a liquid compound that hardens on exposure to air. The screw holes were countersunk and filled flush to the surface of the case with a wood filler. The entire unit was given two coats of Woodlife preservative, then two coats of gray marine enamel.

A heavy rubber glove mounted through the right side of the case permits the photographer to change shutter speeds and lens apertures, to focus, and to wind the movie camera. This glove, a Wil-Gard No. 63-A, size 10, comes with a rolled cuff end (about 1/4 inch in diameter) that closely resembles an O-ring. An aluminum retainer ring is screwed down on the ring, compressing it to form the seal.

A pressure system was required to prevent implosion of the glove and ensure against leakage of water. The mouthpiece was removed from a SCUBA diving regulator, and the inhalation and exhalation hoses were attached to the case. A SCUBA pressurized tank furnished the air supply. The regulator was carefully mounted level with the bottom of the case. This positioning maintains a positive 1/2-pound air pressure inside the case over the surrounding water pressure, irrespective of depth, since the regulator is self-adjusting to changes in water pressure.

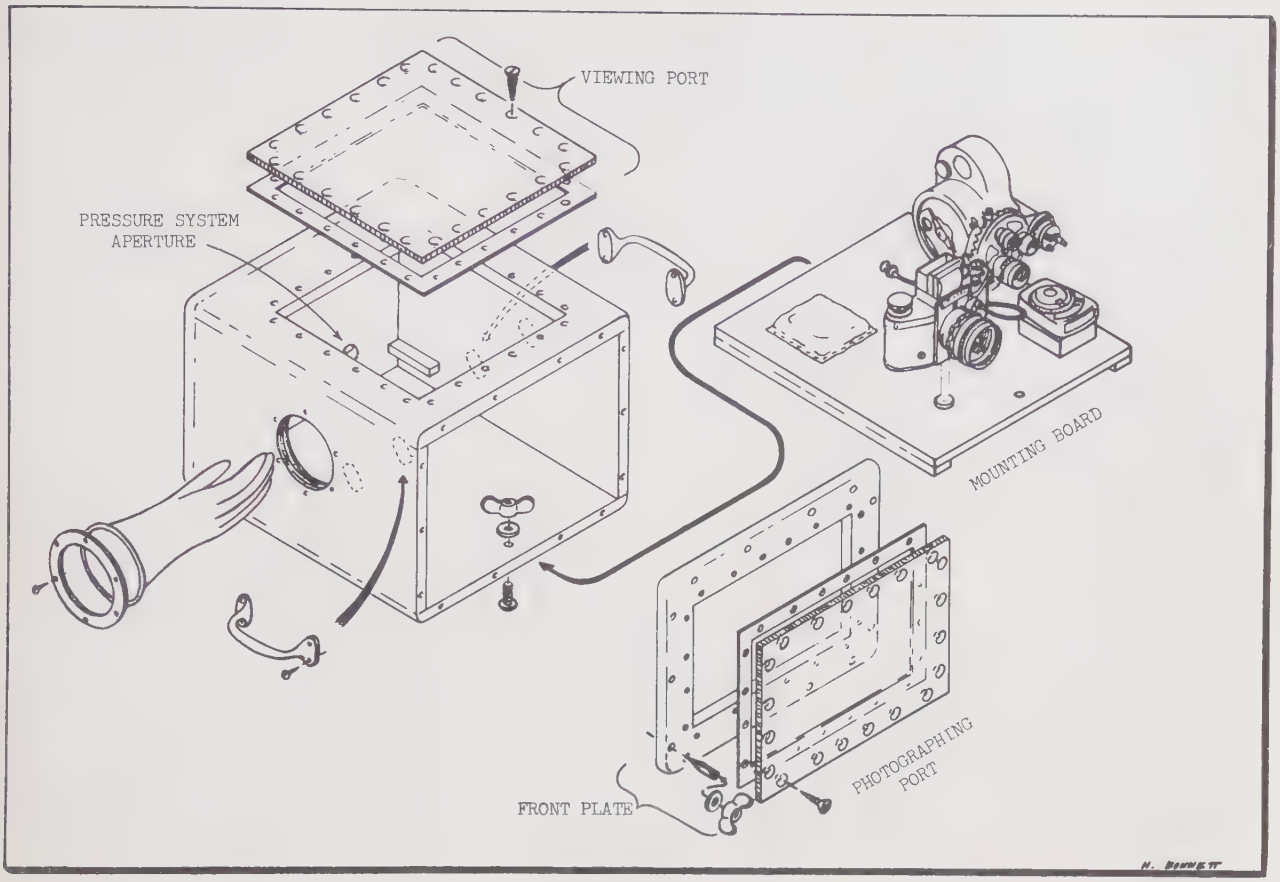

FIGURE 1.--Drawings of underwater camera case.

This differential of pressure on the rubber glove enables easy manipulation of the camera controls and prevents leakage of water.

Two viewing ports were built into the case: one on the front, through which the picture is taken; and one on top, through which the photographer observes operation of the cameras, manipulates the controls, and focuses the Exakta camera (equipped with a waist-level viewfinder). The two ports are covered with 3/8-inch plexiglass acrylic plastic. The plexiglass overlaps the ports by 1 inch and is fastened with brass flathead screws. The sealing gasket is 1/16-inch sheet rubber. Although plexiglass is soft and easily scratched, it is easily worked with woodworking tools. Glass ports would require metal frames and machining that are not available at most field stations. Plexiglass has a lower index of refraction (1.49) than glass (1.53 to 1.59), allowing greater transmission of light and minimizing the effects of minor scratches. Nevertheless, reasonable care must be given to the ports to protect them from damage.

The case is entered through the front to allow easy installation of the camera. The front port is fastened to the case by fourteen 2-1/2-inch hanger bolts and wing nuts.

The case requires a weight of 75 pounds to compensate for water displacement and to achieve neutral buoyancy under water. This weight consists of two 1-inch-thick pieces of boilerplate welded together and suspended by steel rods from two angle-iron members that cross the top of the case. For convenience in carrying, the weight is usually removed when the case is transported out of water.

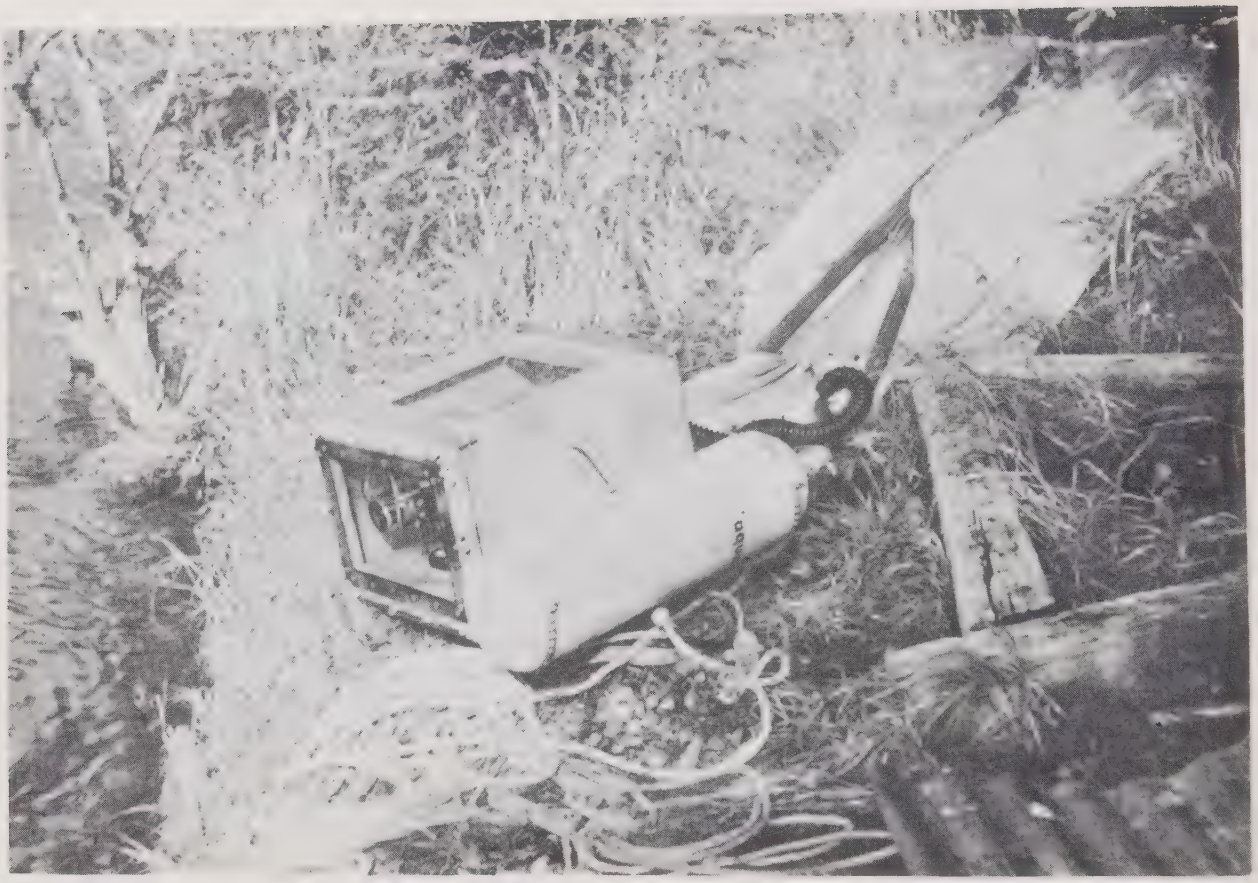

FIGURE 2.--Camera case with ballast and pressure system attached and ready for submerging.

Cameras are secured on a removable mounting board by wing bolts. The Exakta is mounted on a 3-inch post to allow control of the semiautomatic lens-opening feature. Several holes are positioned on the board for mounting the various types of camera used.

Operation

Cameras are aligned on the mounting board, and the wing bolts are tightened down. The board is slid into the case and fitted under the rear retaining bracket, and the front screw is secured. A photoelectric light meter and a 4-ounce bag of silica-gel desiccant are put into the case.

The front port section is aligned with the hanger-bolt studs. The front is lightly struck with the hand, evenly around the perimeter. After the front is worked all the way onto the studs, the washers and wing nuts are placed on the studs. The wing nuts are tightened simultaneously on opposite sides, and two complete circuits are made to ensure uniform compression of the gasket.

Next, the ballast weight is attached to the case. Then the air tank with attached regulator is bolted into a galvanized strap-iron harness on the lower left side of the case. The hoses regulating inhalation and exhalation are clamped on the pipe fittings at the rear of the case. This is done on location to avoid handling excess bulk and weight during transport. The completely assembled underwater camera case is shown in figure 2.

The glove should be inspected periodically for wear or damage. When the case

is dismantled, the front port section must be removed evenly from the hanger bolts to prevent the bending or loosening of the brass bolts.

Discussion

Because of the remoteness of the field station, it was necessary to use some materials that were not best suited for the purpose. The following suggestions are offered to improve design and operation of the case:

1. Seals would be more positive if the 1/16-inch gasket material were replaced with 1/8-inch.

2. Changes made in the design of the front port section to incorporate swiveling wing nuts would speed up the removal or sealing of the front section.

3. Fiberglas might be superior to the enamel paint as a finish.

4. Much time could be saved if the case were constructed in a fully equipped machine and woodworking shop. This experimental case probably cost as much to build as some of the high-quality commercial cases, although most of the cost was for labor, which might be substantially reduced under more efficient working conditions.

Although this underwater camera case was built primarily for photographing the spawning behavior of red salmon in 1959 (figure 3), it is scheduled to be used in other studies at Brooks Lake. Underwater photography will be used to study bottom types, species composition and distribution of submerged attached plants, and distribution of juvenile red salmon, their competitors and predators. In addition, the effectiveness of limnological and netting gear will be evaluated by means of photography.

In conclusion, three features about this underwater camera case should be emphasized. It was constructed with the limited materials available at a remote field station; two cameras of different types were housed simultaneously and could be fully controlled; and, finally, the pressure system was interchangeable with standard SCUBA gear, which would generally be available where underwater photographic projects are contemplated.

FIGURE 3.--Male red salmon on a redd in Brooks River, Alaska.

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1954. Underwater photography and television: a handbook of equipment and techniques. 258 pp. Exposition Press, Inc., New York.

Thompson, W. F., and D. W. Clancy
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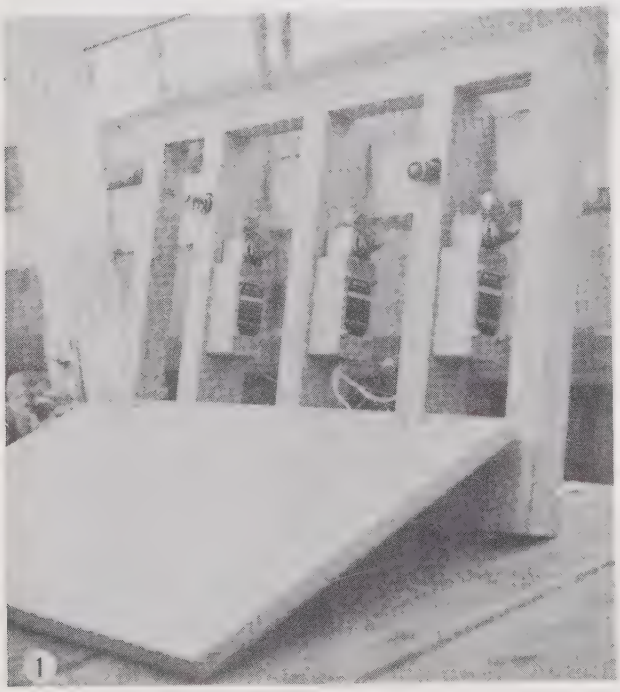
Producers of goldfish and minnows in Missouri have successfully controlled crayfish in their ponds with applications of 8 p.p.m. of parathion.

A SAFETY DEVICE FOR BOAT-MOUNTED SHOCKING EQUIPMENT

Extensive use of boat-mounted shocking equipment has necessitated development of a safety device for operators. Most of the Commission's portable generators were 230/115-volt a. c. -d. c. models. To break the current, a pressure-release switch to handle a 230-volt alternating current at a 15-ampere load was needed. A heavy-duty limit switch, enclosed, waterproof, and taking only 3 pounds of force to work the actuating arm, was used in the pilot model.

Three switches are mounted in a hardwood frame (figure 1) with a hinged cover (3/4-inch marine plywood) that will rest 2 inches above the horizontal at the front, on countersunk spring assemblies. The actuating arms of the switches are raised to come just against the under side of the cover. When the arms are depressed, the circuit is closed. With no weight on the switch-box treadle, the circuit is open.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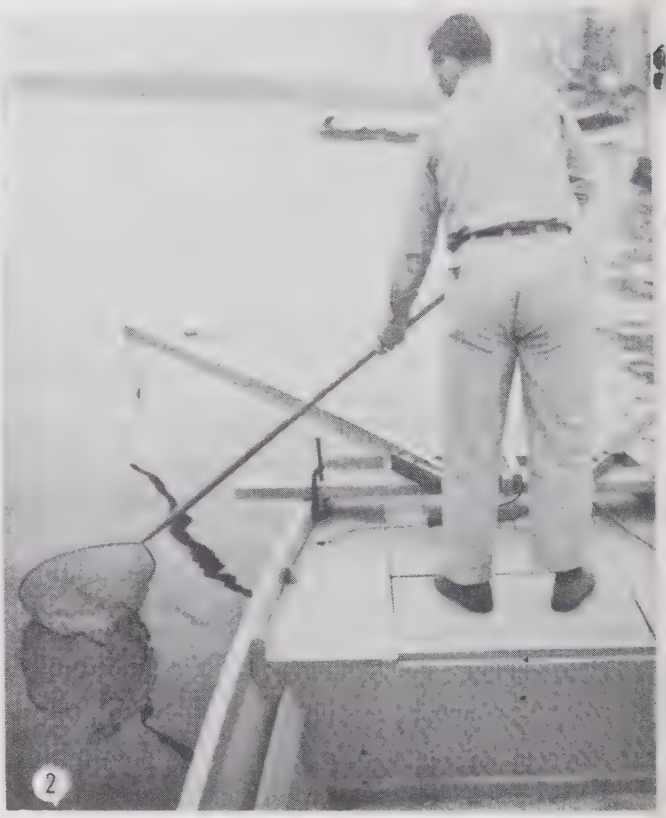
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In wooden flat boats, a deck well can be made for the switch box. It is removable and can be bypassed by plugging the boom assembly into the lead from the generator. It is adaptable to any flat-bottomed or model-hulled boat, as the treadle-support springs are so light that the bow observer can actuate the switches with one foot.

The man on the bow (figure 2) is protected should he slip or be thrown off the deck. The instant he leaves the treadle, the switches open and break the current.

Enclosed switches for heavy field use, moistureproof, and capable of 15-ampere loads, cost $8 to $20 apiece. Other materials--3-conductor wire and connectors, hardware, and lumber--cost less than $5.

--R. E. CLEARY, Iowa Conservation Commission, Independence, Iowa.

Damages awarded recently for pollution valued striped bass at about $6.68 per fish.

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